MOTOROLA

SYNTOR X™

# High Band Systems Radio

150-174 MHz
75 Watts/110 Watts

## Instruction Manual

68P81060E05-O

## COMMERCIAL WARRANTY
## (STANDARD)

Motorola radio communications products are warranted to be free from defects in material and workmanship for a period of ONE (1) YEAR, (except for crystals and channel elements which are warranted for a period of ten (10) years) from the date of shipment. Parts, including crystals and channel elements, will be replaced free of charge for the full warranty period but the labor to replace defective parts will only be provided for One Hundred-Twenty (120) days from the date of shipment. Thereafter purchaser must pay for the labor involved in repairing the product or replacing the parts at the prevailing rates together with any transportation charges to or from the place where warranty service is provided. This express warranty is extended by Motorola Communications and Electronics, Inc., 1301 E. Algonquin Road, Schaumburg, Illinois 60196, to the original purchaser only, and only to those purchasing for purpose of leasing or solely for commercial, industrial, or governmental use.

THIS WARRANTY IS GIVEN IN LIEU OF ALL OTHER WARRANTIES EXPRESS OR IMPLIED WHICH ARE SPECIFICALLY EXCLUDED, INCLUDING WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. IN NO EVENT SHALL MOTOROLA BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES TO THE FULL EXTENT SUCH MAY BE DISCLAIMED BY LAW.

In the event of a defect, malfunction or failure to conform to specifications established by seller, or if appropriate, to specifications accepted by Seller in writing, during the period shown, Motorola, at its option, will either repair or replace the product or refund the purchase price thereof, and such action on the part of Motorola shall be the full extent of Motorola's liability hereunder.

This warranty is void if:

a. the product is used in other than its normal and customary manner;
b. the product has been subject to misuse, accident, neglect or damage;
c. unauthorized alterations or repairs have been made, or unapproved parts used in the equipment.

This warranty extends only to individual products, batteries are excluded, but carry their own separate limited warranty. Because each radio system is unique, Motorola disclaims liability for range, coverage, or operation of the system as a whole under this warranty except by a separate written agreement signed by an officer of Motorola.

Non-Motorola manufactured products are excluded from this warranty, but subject to the warranty provided by their manufacturers, a copy of which will be supplied to you on specific written request.

In order to obtain performance of this warranty, purchaser must contact its Motorola salesperson or Motorola at the address first above shown, attention Quality Assurance Department.

This warranty applies only within the United States.

EPS-27734-O

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# USER QUESTIONNAIRE

**To the User of This Instruction Manual:**

Motorola is engaged in a continuous program of improving its instruction literature. We believe that you can aid us in this program, so that we in turn can better help you service our equipment. To foster these aims, would you please answer the following questions:

## SCHEMATIC DIAGRAMS AND CABLING DIAGRAMS

1. ☐ Are accurate and easy to follow
2. ☐ Contain minor errors
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4. ☐ Are difficult to follow

If you have checked any box except 1, please tell us what schematic diagrams, or portions thereof, were at fault, or enter other comments.*

_____

_____

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_____

_____

3. ☐ Some instruction sections are too long or superfluous such as*

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## AVAILABLE BACKGROUND REFERENCE PUBLICATIONS

Five reference publications are available to provide background information needed to service some of the newer Motorola products more effectively. The information in these publications is not duplicated in our instruction manuals. To obtain your free copy, check the ones you want and return this self-mailer to us. (NOTE: One copy of each publication has already been distributed to Motorola Service Shops (MSS's) and field technical representatives (FTR's).

Check item desired:

☐ **Basic Logic Circuit Guide** 68P81105E88
Describes the basic logic circuits used in Motorola Communications digital equipment and the logic notational scheme used in our instruction manuals.

☐ **"Digital Private-Line" Binary-Coded Squelch** 68P81106E83
Contains fundamentals of "Digital Private-Line" system operation, circuit operation and servicing techniques.

☐ **Safe Handling of CMOS Integrated Circuit Devices** 68P81106E84
Describes special handling techniques needed to prevent irrepairable damage from static charges encountered with normal handling of CMOS devices.

☐ **Reducing Noise Interference in Mobile Two-Way Radio Installations** 68P81109E33
Defines the major sources of noise encountered in a mobile radio installation and suggests methods of remedying them.

☐ **Anti-Skid Braking Precautions** 68P81109E34
Provides installation suggestions and a detailed checkout procedure for installation of mobile radios in vehicles with anti-skid braking systems.

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# FOREWORD

## 1. SCOPE OF MANUAL

This manual is intended for use by experienced technicians familiar with similar types of equipment. It contains all service information required for the equipment described and is current as of the printing date. Changes which occur after the printing date are incorporated by Instruction Manual Revisions (SMR). These SMR's are added to the manuals as the engineering changes are incorporated into the equipment.

## 2. MODEL AND KIT IDENTIFICATION

Motorola equipments are specifically identified by an overall model number on the nameplate. In most cases, assemblies and kits which make up the equipment also have kit model numbers stamped on them. When a production or engineering change is incorporated, the applicable schematic diagrams are updated.

As diagrams are updated, information about the change is incorporated into a revision column. This revision column appears in the manual next to the parts list or, in some cases, on the diagram. It lists the reference number, part number, and description of the parts removed or replaced.

## 3. SERVICE

Motorola's National Service Organization offers one of the finest nation-wide installation and maintenance programs available to communication equipment users. This organization includes approximately 900 authorized Motorola Service Stations (MSS) located throughout the United States, each manned by one or more trained, FCC licensed technicians.

These MSS's are independently owned and operated and were selected by Motorola to service its customers. Motorola maintenance is available on either a time and material basis or on a periodic fixed-fee type arrangement.

The administrative staff of this organization consists of national, area and district service managers and district representatives, all of whom are Motorola employees with the objective to improve the service to our customers.

Should you wish to purchase a service contract for your Motorola equipment, contact your Motorola Service Representative, or write to:

National Service Manager
Motorola Communications and Electronics, Inc.
1303 E. Algonquin Road
Schaumburg, Illinois 60196

## 4. REPLACEMENT PARTS ORDERING

Motorola maintains a number of parts offices strategically-located throughout the United States. These facilities are staffed to process parts orders, identify part numbers, and otherwise assist in the maintenance and repair of Motorola Communications Group products.

Orders for all parts *except* crystals, active filters, code plugs, channel elements, and "Vibrasender" ® and "Vibrasponder" ® resonant reeds should be sent to the nearest area parts center. Orders for instruction manuals should also be sent to the area parts center.

When ordering replacement parts or equipment information, the complete identification number should be included. This applies to all components, kits, and chassis. If the component part number is not known, the order should include the number of the chassis or kit of which it is a part, and sufficient description of the desired component to identify it.

Orders for crystals, channel elements, active filters, PROMs, code plugs, and reeds should be sent directly to the factory address listed on the following page. Crystal and channel element orders should specify the crystal or channel element type number, crystal and carrier frequency, and the chassis model number in which the part is used.

Orders for active filters, PROMs, code plugs, *Vibrasender* and *Vibrasponder* resonant reeds should specify type number and frequency, should identify the owner/operator of the communications system in which these items are to be used; and should include any serial numbers stamped on the components being replaced.

## 5. ADDRESSES

### 5.1 GENERAL OFFICES

MOTOROLA Communications and Electronics Inc.
Communications Group Parts Dept.
1313 E. Algonquin Rd.,
Schaumburg, Illinois 60196
Phone: 312-576-3900

### 5.2 U.S. ORDERS

*WESTERN AREA PARTS*
1170 Chess Drive, Foster City,
San Mateo, California 94404
Phone: 415-349-3111
TWX: 910-375-3877

*MIDWEST AREA PARTS*
1313 E. Algonquin Road
Schaumburg, Ill. 60196
Phone: 312-576-7322
TWX: 910-693-0869

*MID-ATLANTIC AREA PARTS*
7230 Parkway Drive
Hanover, Maryland 20176
Phone: 301-796-8600
TWX: 710-862-1941

*EAST CENTRAL AREA PARTS*
12995 Snow Road,
Parma, Ohio 44130
Phone: 216-267-2210
TWX: 810-421-8845

*EASTERN AREA PARTS*
85 Harristown Road,
Glen Rock, New Jersey 07452
Phone: 201-447-4000
TWX: 710-988-5602

*PACIFIC SOUTHWESTERN AREA PARTS*
P.O. Box 85036
San Diego, California 92138
Phone: 714-578-2222
TWX: 910-335-1634

*GULF STATES AREA PARTS*
8550 Katy Freeway
Suite 128
Houston, Texas 77024
Phone: 713-932-8955

*SOUTHWESTERN AREA PARTS*
P.O. Box 34290
3320 Belt Line Road,
Dallas, Texas 75234
Phone: 214-241-2151
TWX: 910-860-5505

*SOUTHEASTERN AREA PARTS*
P.O. Box 368
Decatur, Georgia 30031
Phone: 504-981-9800
TWX: 810-766-0876

### 5.3 CANADIAN ORDERS

*MOTOROLA LTD.*
National Parts Department
3125 Steeles Avenue East
Willowdale, Ontario M2H 2H6
Phone: 416-499-1441
TWX: 610-492-2713
Telex: 065-25191

### 5.4 ALL COUNTRIES EXCEPT U.S. AND CANADA

*MOTOROLA, INC. OR MOTOROLA AMERICAS, INC.*
International Parts Dept.
1313 E. Algonquin Road
Schaumburg, Illinois 60196 U.S.A.
Phone: 312-576-6492
TWX: 910-693-0869
Telex: 722443 or 722424
Cable: MOTOL PARTS

### 5.5 FACTORY ADDRESS FOR CRYSTAL, CHANNEL ELEMENT, ACTIVE FILTER, CODE PLUGS, PROMs, AND RESONANT REED ORDERS

*ALL MAIL ORDERS*
Motorola, Inc.
Component Products Sales & Service
P.O. Box 66191
O'Hare International Airport
Chicago, Ill. 60666

*CORRESPONDENCE*
Motorola, Inc.
Component Products Sales & Service
2553 N. Edgington Street
Franklin Park, Illinois 60131

## PERFORMANCE SPECIFICATIONS

### *GENERAL*

| | |
|---|---|
| Number of Modes | Models available in 8-, 16-, and 32-mode configurations |
| Channel Resolution | Multiplex of 5.0 kHz or 6.25 kHz |
| Squelch Options | *Private-Line* and *Digital Private-Line* coded squelch are standard and available within the same radio unit. Carrier squelch and multiple coded squelch are optional. |
| Primary Power | ±12 V dc using a dc isolated floating ground system. Radio supplied for operation with negative ground vehicles. Optional cable kit permits operation with positive ground vehicles. |
| Radio Unit Dimensions | 2.5" H x 11.5" W x 16.0" L (63.5mm x 292mm x 406mm) |
| Radio Unit Weight | Approximately 22.5 lbs. (10.2 kg). Shipping weight approximately 37.5 lbs. (17 kg) |
| Metering | A single scale 0-50 microampere meter or Motorola portable test set can be used to measure all circuits essential to checking and adjustments. |

| | | | Maximum Battery Drain (inc. std. accessories) | | |
|---|---|---|---|---|---|
| **Model (Series)** | **Frequency MHz** | **Minimum RF Power Output** | **Standby @ 13.8 V** | **Receive at Rated Audio @ 13.8 V** | **Transmit @ Rated Power** |
| T83VBJ | 150-174 | 110 W Variable to 55 W | 0.9A | 3.3A | 27A |
| T53VBJ | 150-174 | 75 W Variable to 55 W | 0.9A | 3.3A | 22A |

### *TRANSMITTER*

| | |
|---|---|
| Output Impedance | 50 ohms |
| Spurious and Harmonic Emissions | More than 85 dB below carrier (for EIA spec. RS152B) |
| Frequency Stability | ±.0002% of assigned center frequency from −30°C to +60°C ambient (+25°C reference) |
| Maximum Frequency Separation | 24 MHz without degradation |
| Modulation | 15F2 & 16F3, ±5 kHz for 100% @ 1000 Hz |
| Audio Sensitivity | 0.080 V ±3 dB for 60% maximum deviation @ 1000 Hz |
| FM Hum and Noise EIA Method<br>Companion Rcvr Response<br>RS152B Response | <br>−65 dB<br>−55 dB |
| Audio Response | +1, −3 dB of 6 dB/octave pre-emphasis characteristic from 300 to 3000 Hz |
| Audio Distortion | Less than 2% @ 1000 Hz, 60% maximum deviation |
| FCC Designation | CC3372 — Licensable under FCC rules Parts 22, 74 and 90 for 15F2, 16F3 and 16F9 emission. |

### *CONTROL HEAD*

| **Type** | **Rotary (Std.)** | **Pushbutton (opt.)** |
|---|---|---|
| Dimensions:<br>excluding mounting bracket | 6-7/8" W x 2" H x 3-3/4" D<br>(175mm x 51mm x 95mm) | 6-7/8" W x 2-1/4" H x 5-3/4" D<br>(175mm x 57mm x 146mm) |
| Weight | 1 lb. (453 g) | 1.5 lb. (680 g) |
| Current Drain | 150 mA | 500 mA |

### *SPEAKER*

| | |
|---|---|
| Dimensions:<br>(excluding mounting bracket) | 5" x 5" x 2-1/2" (127mm x 127mm x 63mm) |
| Weight | 1.5 lbs. (680 g) |

### *RECEIVER*

| | |
|---|---|
| Input Impedance | 50 ohms |
| EIA Modulation Acceptance | ±7.0 kHz minimum |
| Frequency Stability | ±.0002% of assigned center frequency from −30°C to +60°C ambient (±25°C reference) |
| Maximum Frequency Separation | 24 MHz without degradation |

| Sensitivity | **With Pre-Amp** | **Without Pre-Amp** |
|---|---|---|
| 20 dB quieting | 0.25 uV | 0.50 uV |
| EIA SINAD | 0.175 uV | 0.35 uV |
| Intermodulation<br>EIA SINAD | 80 dB | 85 dB |
| Spurious & Image Rejection | 85 dB | 90 dB |

| **Selectivity EIA SINAD** | **Adjacent Channel** | **Alternate Channel** | **4th Channel** | **±400 kHz** |
|---|---|---|---|---|
| 30 kHz Ch. | 90 dB | 95 dB | 100 dB | 110 dB |
| 25 kHz Ch. | 85 dB | 90 dB | 95 dB | 110 dB |

## PERFORMANCE SPECIFICATIONS (Cont'd.)

| | |
|---|---|
| Squelch Sensitivity | Carrier squelch (at threshold setting), Tone-Coded Squelch (fixed), Digital-Coded Squelch (fixed), are all 6 dBq (0.25 uV max. w/o preamp; 0.13 uV with preamp) |
| Audio Output | 15 watts @ less than 3% distortion into an 8-ohm load |
| FCC Designation | RC0291 |

### *SYSTEMS 90•S OPTIONS*

- *Quik-Call II* Signaling
- *Touch Code* Signaling
- Single Tone Signaling
- EMS Accessory Group
- Digital Dial Signaling
- Electronic Siren and Public Address
- Mobile Public Address
- VPA (Speech Scrambler)
- Auxiliary Switch Panel

## *SYNTOR X*

## HIGH-BAND SYSTEMS RADIO

## 150-174 MHz

## T83VBJ MODELS: 110 W VARIABLE TO 55 W

## T53VBJ MODELS: 75 W VARIABLE TO 55 W

CODE:

• = ONE ITEM SUPPLIED

★ = INDICATES BREAKDOWN IN SEPARATE CHART

| ITEM | DESCRIPTION | T83VBJ7204AK | T53VBJ7204AK | T83VBJ7D04AK | T53VBJ7D04AK | T83VBJ7J04AK | T53VBJ7J04AK |
|---|---|---|---|---|---|---|---|
| | MODEL DESCRIPTION | 8-MODE, 110 W-55 W | 8-MODE, 75-55 W | 16-MODE, 110 W-55 W | 16-MODE, 75 W-55 W | 32-MODE, 110 W-55 W | 32-MODE, 75 W-55 W |
| HUD1090A ★ | UNIFIED CHASSIS, CODED SQUELCH | • | • | • | • | • | • |
| HCN1009A | CONTROL HEAD, 8-MODE | • | • | | | | |
| HCN1019A | CONTROL HEAD, 16-MODE | | | • | • | | |
| HCN1020A | CONTROL HEAD, 32-MODE | | | | | • | • |
| HAD4002A | ANTENNA, BROADBAND | • | • | • | • | • | • |
| HKN4051A | POWER CABLE AND FUSE KIT | • | • | • | • | • | • |
| HKN4052A | CABLE, CONTROL HEAD POWER | • | • | • | • | • | • |
| HLN1050A | MEMORY MODULE, 8- AND 16-MODE | • | • | • | • | | |
| HLN1051A | MEMORY MODULE, 32-MODE | | | | | • | • |
| HLN4188A | MICROPHONE HANGUP BOX | • | • | • | • | • | • |
| HLN4208A | TRUNNION AND BREAKAWAY | • | • | • | • | • | • |
| HLN4111A | INSTALLATION KIT | • | • | • | • | • | • |
| HLN4243A | COVER, BOTTOM | • | • | • | • | • | • |
| HLN4262A | TUNING TOOL | • | • | • | • | • | • |
| HLN4263A | COVER, TOP | • | • | • | • | • | • |
| HLN4264A | MOUNTING TRAY | • | • | • | • | • | • |
| HMN4002A | MICROPHONE | • | • | • | • | • | • |
| HSN4005A | SPEAKER | • | • | • | • | • | • |
| TKN8087A | RADIO CABLE KIT | • | • | • | • | • | • |

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# *SYNTOR X*

# HIGH-BAND SYSTEMS RADIO

# UNIFIED CHASSIS

# MODEL CHART

**CODE:**

● = ONE ITEM SUPPLIED

| MODEL | DESCRIPTION | HUD1090A | HUD1091A | HUD1092A | HUD1093A | HUD1098A |
|---|---|---|---|---|---|---|
| | UNIFIED CHASSIS, CODED SQUELCH | | | | | |
| | UNIFIED CHASSIS, CARRIER SQUELCH (USED WITH W478) | | | | | |
| | UNIFIED CHASSIS, CODED SQUELCH WITH PREAMP (USED WITH W12) | | | | | |
| | UNIFIED CHASSIS, CARRIER SQUELCH WITH PREAMP (USED WITH W12 & W478) | | | | | |
| | UNIFIED CHASSIS, CODED SQUELCH HI/LO TRANSMIT POWER (USED WITH W277) | | | | | |
| HLD1048A | INTERNAL CASTING ASSEMBLY | ● | ● | | | ● |
| HKN4066A | CABLE KIT | ● | ● | | | ● |
| HLD4103A | VCO | ● | ● | | | ● |
| HLD4108A | FIRST MIXER | ● | ● | | | ● |
| HLN1053A | VCO BUFFER | ● | ● | | | ● |
| HLN4250A | LOW PASS FILTER | ● | ● | | | ● |
| HLN4251A | VCO INTERCONNECT | ● | ● | | | ● |
| HLN4260A | INTERNAL CASTING HARDWARE | ● | ● | | | ● |
| HLN4261A | INTERNAL CASTING | ● | ● | | | ● |
| HLD1053A | INTERNAL CASTING ASSEMBLY | | | ● | ● | |
| HKN4066A | CABLE KIT | | | ● | ● | |
| HLD4108A | FIRST MIXER | | | ● | ● | |
| HLD4103A | VCO | | | ● | ● | |
| HLD4123A | PREAMPLIFIER | | | ● | ● | |
| HLN1053A | VCO BUFFER | | | ● | ● | |
| HLN4251A | VCO INTERCONNECT | | | ● | ● | |
| HLN4260A | INTERNAL CASTING HARDWARE | | | ● | ● | |
| HLN4261A | INTERNAL CASTING | | | ● | ● | |
| HLN1049A | PERSONALITY & I/O BOARDS | ● | | ● | | ● |
| TRN8876A | INPUT/OUTPUT BOARD | ● | | ● | | ● |
| HLN4257A | PERSONALITY BOARD | ● | ● | ● | ● | ● |
| HKN4068A | INTERCONNECT BOARD | | | | | ● |
| HKN4065A | INTERCONNECT CABLE | ● | ● | ● | ● | ● |
| HLD4067A | PA POWER TRANSISTORS | ● | ● | ● | ● | ● |
| HLD4076A | PA BOARD | ● | ● | ● | ● | |
| HLN4046A | PA FEEDTHRU PLATE | ● | ● | ● | ● | ● |
| HLN4239A | RF BOARD | ● | ● | ● | ● | ● |
| HLN4240A | COMMON CIRCUITS BOARD | ● | ● | ● | ● | ● |
| HLN4241A | ANTENNA SWITCH | ● | ● | ● | ● | ● |
| HLN4242A | DIRECTIONAL COUPLER | ● | ● | ● | ● | ● |
| HLN4244A | IPA FEEDTHRU PLATE | ● | ● | ● | ● | ● |
| HLN4245A | PA HARDWARE | ● | ● | ● | ● | |
| HLN4246A | MODEL HARDWARE | ● | ● | ● | ● | ● |
| HLN4247A | IPA BOARD | ● | ● | ● | ● | ● |
| HLN4248A | BUS WIRES | ● | ● | ● | ● | ● |
| HLN4259A | FRONT HARDWARE | ● | ● | ● | ● | ● |
| HLD4116A | PA BOARD | | | | | ● |
| HLN4269A | PA HARDWARE | | | | | ● |
| HLN4268A | ATTENUATOR SWITCH | | | | | ● |
| HLN4271A | ATTENUATOR MODULE | | | | | ● |
| HLN4270A | INTERFACE BOARD | | | | | ● |
| HFD4000A | HARMONIC FILTER | | | | | ● |

## OPTIONS CHART

| Options | Description |
|---|---|
| W11___ | Time-out timer (60 seconds) |
| W12___ | RF preamplifier |
| W54___ | Positive ground cable |
| W71___ | Omit microphone |
| W87___ | Omit speaker |
| W90___ | Omit all accessories |
| W101___ | 22-foot negative ground cable |
| W109___ | Handset w/hangup |
| W204___ | Double *Systems 90•S* housing with trunnion extenders |
| W239___ | Noise-cancelling microphone |
| W261___ | High/medium power (110 watt/55 watt) |
| W269___ | Siren, hi-lo tone |
| W271___ | Siren, steady tone |
| W277___ | High/low power (110 watt/10 watt) |
| W415___ | Multi-coded squelch 4-code operator select |
| W416___ | Multi-coded squelch 8-code operator select |
| W417___ | 8-frequency operator select scan |
| W420___ | *Channel Scan* w/display, 8-mode rotary control |
| W421___ | Second priority for channel scan |
| W422___ | 2-frequency sequential scan (internally programmed by mode) |
| W425___ | Repeater/talkaround (selected by a switch) |
| W427___ | "AND" opening squelch |
| W428___ | Time-out timer (duration variable by mode) |
| W478___ | Delete coded squelch |
| W492___ | Priority channel scan, 2-frequency (internally programmed by mode) |
| W493___ | *Systems 90•S* single housing |
| W494___ | Mode-select, multi-coded squelch |
| W495___ | Scan display w/pushbutton mode select |
| W496___ | 10-foot negative ground cable |
| W543___ | Headset w/lip microphone |
| W545___ | Digital dial encoder, 2805 Hz |
| W546___ | Digital dial encoder, 2805 Hz |
| W554___ | *Touch Code* encoder |
| W562___ | *Quik-Call II* decoder, individual call |
| W563___ | *Quik-Call II* decoder, individual & group call |
| W564___ | One-tone, single-tone |
| W566___ | Five-tone, single-tone |
| W580___ | Voice privacy adapter |
| W582___ | Digital dial encoder, 1500 Hz |
| W583___ | Digital dial decoder, 1500 Hz |
| W585___ | *Touch Code* decoder, individual call |
| W586___ | "EMS" accessory group with headset and foot switch |
| W587___ | "EMS" accessory group with handset |
| W589___ | Public address module |
| W591___ | Auxiliary switch panel |
| W599___ | Pushbutton control head, 8-mode |
| W614___ | Pushbutton control head, 16-mode |
| W615___ | Pushbutton control head, 32-mode |
| VB7601A | Spare accessory group, 8-mode |
| VB7602A | Spare accessory group, 16-mode |
| VB7603A | Spare accessory group, 32-mode |

# GENERAL SAFETY INFORMATION

The United States Department of Labor, through the provisions of the Occupational Safety and Health Act of 1970 (OSHA), has established an electromagnetic energy safety standard which applies to the use of this equipment. Proper use of this radio will result in exposure below the OSHA limit. The following precautions are recommended:

DO NOT operate the transmitter of a mobile radio when someone outside the vehicle is within two feet (0.6 meter) of the antenna.

DO NOT operate the transmitter of a fixed radio (base station, microwave and rural telephone rf equipment) or marine radio when someone is within two feet (0.6 meter) of the antenna.

DO NOT operate the transmitter of any radio unless all RF connectors are secure and any open connectors are properly terminated.

In addition,

DO NOT operate this equipment near electrical blasting caps or in an explosive atmosphere.

All equipment must be properly grounded according to Motorola installation instructions for safe operation.

All equipment should be serviced only by a qualified technician.

Refer to the appropriate section of the product service manual for additional pertinent safety information.

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**WARNING**

For vehicles equipped with electronic anti-skid braking systems see "ANTI-SKID BRAKING PRECAUTIONS" Publication, Motorola Number 68P81109E34.

**WARNING**

To gain full access to the Common Circuits Board for servicing, the regulator heat sink screw must be removed. When operating the radio with the regulator heat sink screw removed, care should be taken to avoid the exposed hot flange.

## 1. INTRODUCTION

The 150-174 MHz *SYNTOR X* Systems Radio (Figures 1 and 2) is a microcomputer-controlled transceiver employing all solid-state circuitry and state-of-the-art frequency synthesizer to generate all required frequencies.

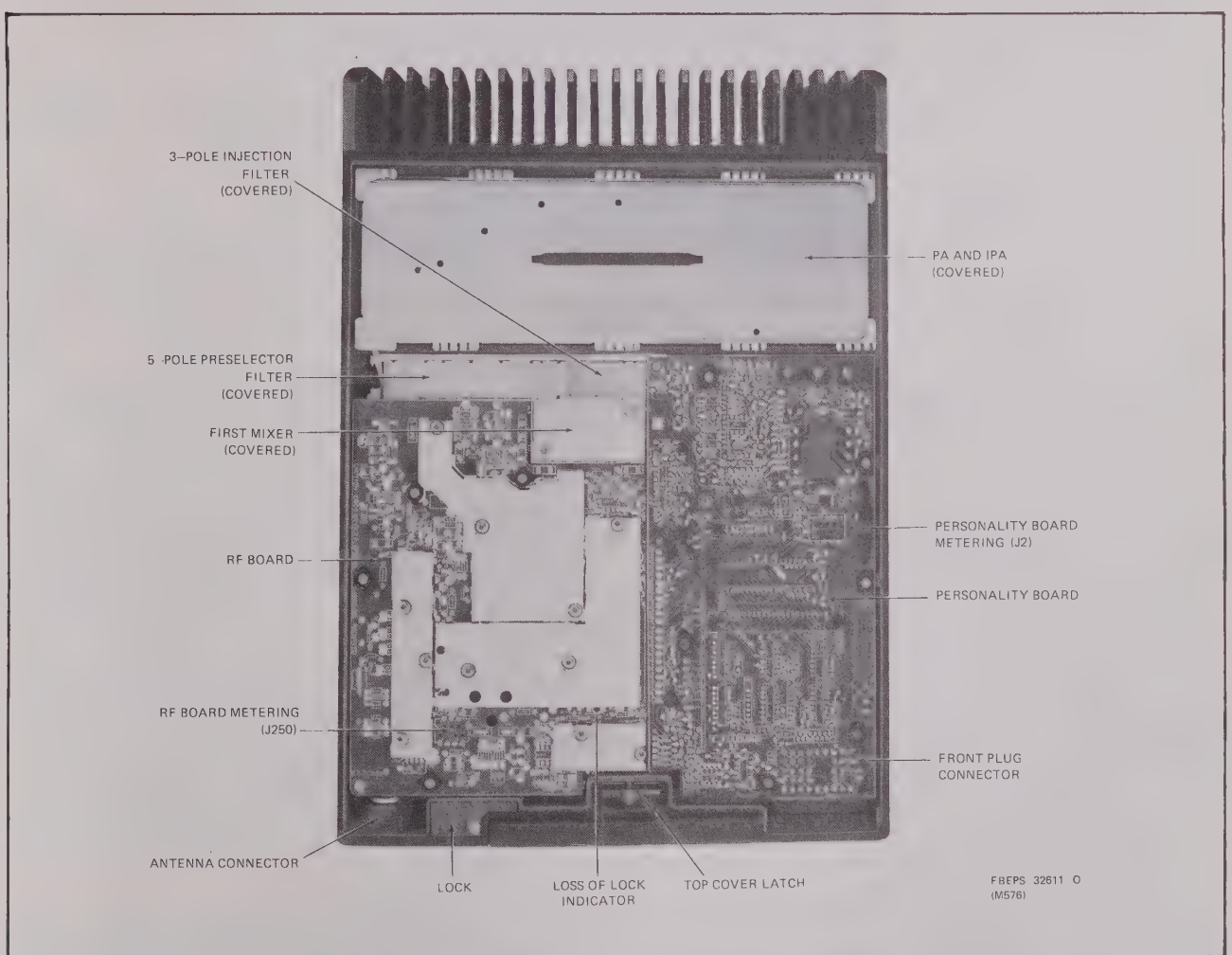



*Figure 1. Top View of SYNTOR X High-Band Systems Radio*

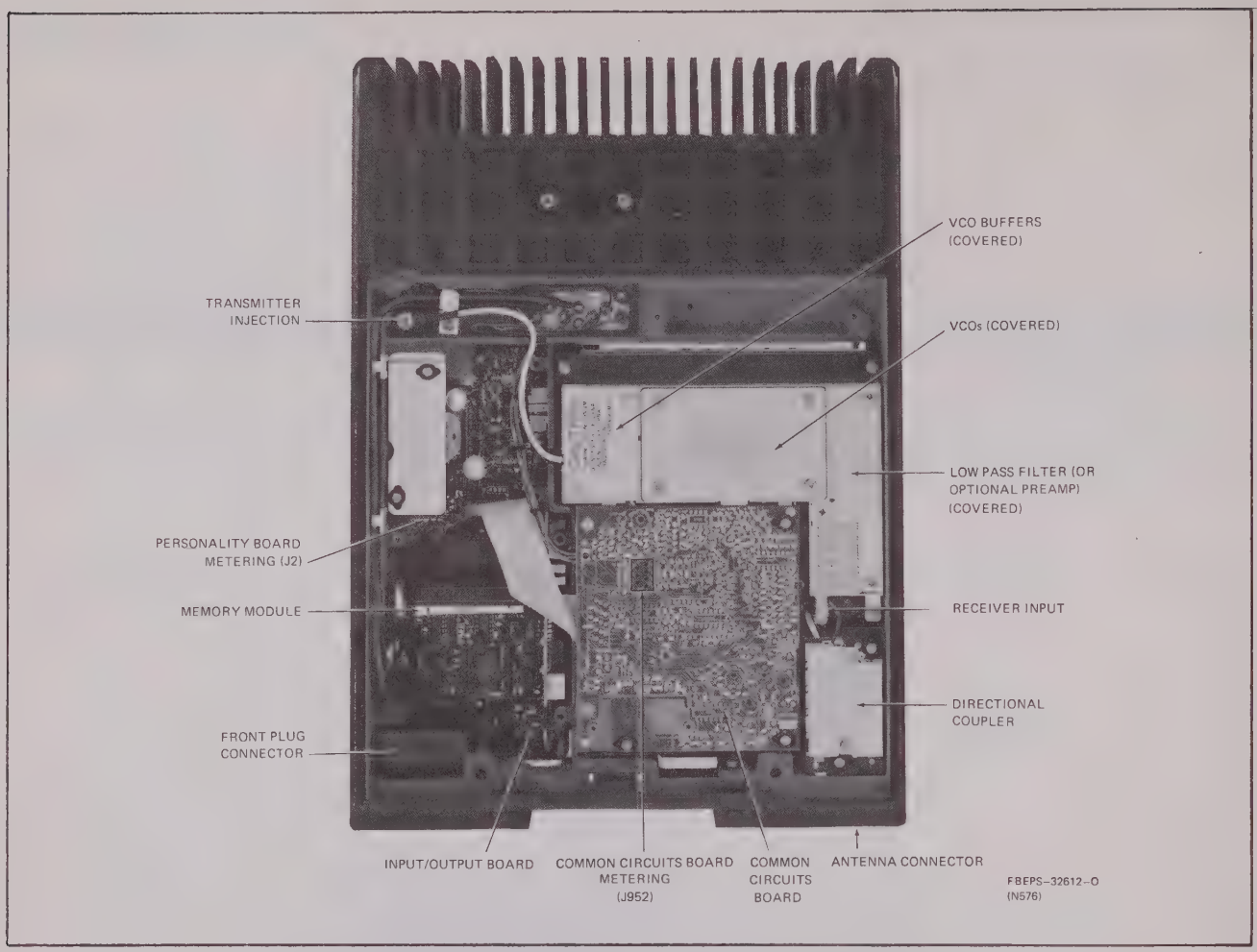



*Figure 2. Bottom View of* ***SYNTOR X*** *High-Band Systems Radio*

## 2. *SYNTOR X* RADIO FEATURES

### 2.1 STANDARD FEATURES

The *SYNTOR X* high-band radio provides the following standard features:

- TRAC-MODE microcomputer-controlled system
- mode-select operation
- broad-band 24 MHz transmitter and receiver
- frequency synthesizer
- *Private-Line* and *Digital Private-Line* code squelch
- rugged construction that meets MIL-STD-810C specifications related to rain, dust, salty atmosphere, shock, and vibration
- all solid-state, compact, modular design that simplifies radio maintenance and troubleshooting.

Some of these standard features are discussed below:

#### 2.1.1 TRAC-MODE Microcomputer-Controlled Operation

Major radio set operations are controlled by an 8-bit microcomputer that reads the user-specified operating parameters from a memory module. These parameters include:

- transmit and receive frequencies
- *Private-Line* or *Digital Private-Line* squelch codes
- *Channel Scan* operation
- time-out timing
- "AND" or standard squelch
- transmit output power.

This permits the radio to be customized to meet specific user requirements. Operational modifications are implemented by simply replacing the existing memory module with one that has been programmed according to the user's requirements. Consequently, a *SYNTOR X* radio can be moved between fleets having different operating parameters with relative ease.

### 2.1.2 Mode Select Operation

Mode select operation is a major feature of the TRAC-MODE system, discussed in the preceding paragraphs. Since the operator has only one switch to control, radio operation is simplified and the chance of missing messages is greatly reduced. A "mode" consists of a list of functions performed on a channel. The mode select options place various auxiliary functions under control of the control head selector switch, thus eliminating the need for separate controls and control heads. The mode select feature allows the operator to simultaneously select:

- the transmit and receive frequency or frequencies
- *Private-Line* operation on some channels, *Digital Private-Line* or carrier squelch (CSQ) on others; also "slaved" multiple *Private-Line* or *Digital Private-Line* squelch select (transmit or receive)
- *Private-Line* (or *Digital Private-Line*) squelch disable
- *Channel Scan* monitoring, including the ability to specify the channels to be scanned as well as the priority level associated with each scanned channel
- time-out timer duration
- transmitter output power selection — two levels between 55 and 110 watts.

### 2.1.3 Broad-Band 24 MHz Operation

The *SYNTOR X* high-band radio can transmit and receive on any combination of authorized frequencies which are multiples of 5.0 kHz or 6.25 kHz in the entire 150-174 MHz range without incurring any degradation in performance. The *SYNTOR X* radio has been designed to eliminate the need for special "dual exciter" or "dual front end" circuits that operate on widely separated channels. The radio frequencies can be changed or added without requiring retuning or realignment of the set.

### 2.1.4 Frequency Synthesis

The *SYNTOR X* employs a synthesizer that can electronically generate all the required frequencies, thus eliminating the need for individual channel elements. The synthesizer incorporates a "fast-locking" feature to handle priority *Channel Scan* monitoring options as well as data applications that require fast frequency switching.

### 2.1.5 Improved Transmitter and Receiver Performance

The *SYNTOR X* high-band radio features 24 MHz receive bandwidth without degradation, 24 MHz transmit bandwidth without degradation, frequency stability rated at ±2 ppm, and transmit audio distortion rated at less than 2%. Receiver sensitivity (without a preamplifier) is rated at 0.35 microvolts (EIA SINAD) over the full 24 MHz bandwidth.

### 2.1.6 *Private-Line* and *Digital Private-Line* Coded Squelch

The *Private-Line* or *Digital Private-Line* coded squelch is programmed into the memory module as required. This feature allows the operators to hear only those messages that use their individual system code, thus reducing operator listening fatigue as well as the probability of missed or misunderstood messages.

### 2.1.7 Positive/Negative Ground System

The *SYNTOR X* high-band radio is designed to operate in vehicles employing positive or negative ground systems. The only requirement is that a cable kit with the correct polarity be used. Separate converter kits are not required.

## 2.2 OPTIONAL FEATURES

The *SYNTOR X* high-band radio provides the following optional features:

- repeater/talkaround capability
- mode-selectable *Private-Line* and *Digital Private-Line*
- multiple *Private-Line* and *Digital Private-Line*, operator-selectable coded-squelch operation
- mode-select *Channel Scan* operation
- operator-select *Channel Scan* operation
- programmable time-out timer
- programmable "AND" opening squelch
- mode-selectable transmitter output power — two levels: 55/110 watts (on T83VBJ) or 55/75 watts (on T53VBJ)
- preamplifier
- multi-mode pushbutton control head
- *Systems 90•S* options.

### 2.2.1 Repeater Talk-Around Capability

Repeater Talk-Around provides direct communication between two mobile units or between a mobile radio and a portable unit. Talk-around operation is selected by setting either the MODE-SELECT switch, a separate pushbutton, or toggle switch.

### 2.2.2 Multiple *Private-Line* and *Digital Private-Line* Coded Squelch

Multiple *Private-Line* and *Digital Private- Line* coded squelch is programmed into the memory module and is activated by means of the MODE-SELECT switch. Coded squelch is used for repeater access, selective call, and other system uses. This feature allows a radio unit to operate into both *Private-Line* and *Digital Private-Line* systems. All *Private-Line* and *Digital*

*Private-Line* squelch codes are programmed into the memory module, making both types of coded squelch as well as carrier squelch available in the same *SYNTOR X* radio. Transmit codes may differ from receive codes without imposing any operational restrictions. All standard CTCSS (continuous-tone carrier-squelch systems) and *Digital Private-Line* codes are available. This feature allows a *SYNTOR X* radio to operate in systems having different squelch codes — single, multiple, or mixed. Codes can be changed by simply plugging an appropriately programmed memory module into the radio.

### 2.2.3 Mode-Select *Channel Scan* Operation

The *Channel Scan* parameters are preprogrammed into the memory module and are activated by means of the MODE-SELECT switch. *Channel Scan* operation is greatly simplified since this is the only switch or control that has to be operated by the operator.

### 2.2.4 Operator-Select *Channel Scan*

Operator-Select *Channel Scan* allows the operator to manually select from one to eight nonpriority channels. This is suited to operators who prefer manual *Channel Scan* operation.

### 2.2.5 Preamplifier

Use of the optional preamplifier improves the 12 dB SINAD receiver sensitivity from 0.35 microvolts to 0.175 microvolts, with a 5 dB decrease in intermodulation protection.

### 2.2.6 Time-Out Timer

When the time-out timer is preprogrammed into the memory module, this time option causes the transmitter to cease transmission either (a) after a fixed period of 60 seconds, or (b) after a duration ranging from a minimum of 15 seconds to a maximum of 7 minutes and 45 seconds, in 15-second increments, according to the information programmed into the memory module. This timer option prevents repeater or channel tie-up because of prolonged keying of the transmitter.

### 2.2.7 "AND" Opening Squelch Option

When the "AND" opening squelch (option) is preprogrammed into the memory module, it will cause the audio to unmute when both the proper signal strength (whose level is set by means of the SQUELCH control) and the proper code (*Private-Line* or *Digital Private-Line*) are present. This squelch option provides the advantages of *Private-Line* or *Digital Private-Line* for privacy and protection against fading signals yet it allows the operator to select the signal quality required to unmute the receiver while "on-hook". It can also be used to eliminate messages coming from distant co-channel users having the same frequency and *Private-Line/Digital Private-Line* code.

### 2.2.8 Pushbutton Control Head

The pushbutton control head is available as an optional substitute to the standard rotary-select control head. The pushbutton control head is available in 8-, 16-, and 32-mode configurations. The optional *Channel Scan* monitoring display (W495) permits frequency monitoring up to the capacity of the pushbutton control head, in groups of eight.

### 2.2.9 Selectable Transmit Output Power

The transmit output power level can be programmed into the radio so that it can be mode-selectable, as explained below:

- 55 and 110 watts (on the T83VBJ models)
- 55 and 75 watts (on the T53VBJ models).

## 3. ELECTRICAL CHARACTERISTICS

The basic *SYNTOR X* radio consists of a single-frequency unit that operates from a negative-ground, 12-volt dc source, a rotary-mode-select control head, speaker, microphone with a hangup box, a broadband 1/4-wave unity-gain antenna with a 16-1/2-foot cable, and a 17-foot negative-ground cable kit. The basic radio also is provided with coded squelch capability that accommodates both *Private-Line* and *Digital Private-Line* coding.

### 3.1 CIRCUIT BLOCKS

The *SYNTOR X* high-band radio is grouped into the following physical blocks: personality board, input/output (I/O) board, memory module, common circuits board, 110-watt power amplifier, radio frequency (rf) board, directional coupler board, and internal casting. The internal casting comprises a voltage-controlled oscillator (VCO), low-pass filter board (or optional preamplifier), mixer, 5-pole filter, 3-pole filter, and VCO buffers.

### 3.2 FUNCTIONAL DESCRIPTION

The *SYNTOR X* radio can be funtionally divided into four parts: (a) microcomputer, (b) frequency synthesizer, (c) receiver, and (d) transmitter. The microcomputer circuits are contained on the personality board; the frequency synthesizer circuits are contained on the common circuits board, rf board, and internal casting; the receiver circuits are contained on the personality board, common circuits board, rf board, and internal casting; and the transmitter circuits are contained on the common circuits board, directional

coupler board, and power amplifier. A brief description of each functional segment is provided below; further description is provided in the section associated with the circuit in question.

### 3.2.1 Microcomputer

The personality board is controlled by an 8-bit microcomputer. This board is equipped with a 3.6 MHz clock crystal for the microcomputer, which has its own crystal oscillator circuitry. The user- specified operating parameters are read by the microcomputer from a preprogrammed memory as the transmit/receive frequencies, *Private-Line* or *Digital Private-Line* codes, *Channel Scan*, time-out timing, and squelch codes. The operating mode of the *SYNTOR X* radio is selected by means of the MODE SELECT switch on the control head. This switch not only determines the transmit and receive frequencies but also selects a specific set of operating parameters as preprogrammed into the memory module.

### 3.2.2 Frequency Synthesizer

The frequency synthesizer uses a phase-locked loop (PLL) consisting of a reference oscillator, voltage-controlled oscillator (VCO), programmable divide-by-3-or-4 prescaler, multiplex divider, sample-and-hold phase detector, loop adaptive filter, and VCO buffers. For frequency generation and control, the proper information is read out from the memory module by the microcomputer and then applied to the multiplex divider via four data lines. This information is contained in six 4-bit words. A multiplexing sequence is used to pass the six words to the multiplex divider. The multiplex divider is used to divide the reference oscillator frequency and generate four bits. Two of these bits (C0 and C1) control a "C" counter that is internal to the divide-by-3-or-4 prescaler; the two other bits (S0 and S1) are used by the sample-and-hold phase detector to control the loop adaptive filter. Once the mode of operation and the channel are selected, the six 4-bit words stay the same. However, any change in mode causes different memory locations in the memory module to be addressed by the microcomputer. Consequently, the six 4-bit words will supply different information to the multiplex divider, via the four data lines. Microphone audio from the personality board is applied to the IDC circuitry along with the PL/DPL encode siganls (if used). The IDC circuits process the audio to ensure that the proper level of audio drive is supplied to the frequency synthesizer. In *Private-Line/Digital Private-Line* radios, the low-frequency PL/DPL encode signals from the personality board are combined with the microphone audio signal and routed to the VCO and the synthesizer reference oscillator via the deviation and compensation circuits.

### 3.2.3 Receiver

The incoming rf signals are applied to the low-pass filter board (or optional preamplifier) via the antenna relay. The low-pass filter output passes through a 5-pole preselector filter and is then applied to the first mixer stage. The selectivity of the two filters is such that it prevents high-level, out-of-band signals from degrading receiver performance. The *SYNTOR X* radio does not employ receiver channel elements to generate the first mixer injection frequency. Rather, the frequency synthesizer output provides a high side injection frequency which is applied to the first mixer via a 3-pole injection filter. The first mixer generates an i-f (intermediate frequency) of 53.9 MHz that is sufficiently amplified by two amplifiers so that it will be able to drive the second mixer. The second mixer uses the 53.9 MHz signal and a 43.2 MHz signal from an injection tripler to generate a 10.7 MHz i-f. The receiver uses a 6-pole and 4-pole 10.7 MHz crystal filter that substantially attenuates signals outside the predetermined receiver bandpass range. After filtering and amplification, the 10.7 MHz signal passes to the limiter/detector stage. The squelch circuit provides the microcomputer with two signals (CHANNEL ACTIVITY and SQUELCH TAIL). In the absence of an rf carrier, both signals are in a low state. When an rf carrier appears, both signals switch to a high state to notify the microcomputer to enable the audio stages. The faster CHANNEL ACTIVITY line is used as a preliminary indicator during *Channel Scan* operation, while the SQUELCH TAIL line provides fade protection for the audio signals.

### 3.2.4 Transmitter

The rf output generated by the frequency synthesizer at the required transmit frequency is applied to the controlled stage of the intermediate power amplifier (IPA) of the transmitter. The rf signal passes from the IPA to a power amplifier, via a coaxial cable, and is applied to the predriver stage. The predriver stage is followed by a driver stage, and both stages provide sufficient output to drive the two final power amplifiers. The transmitter is provided with a temperature-sensing circuit that protects the final power amplifier against damaging high temperatures. The temperature-sensing circuit works in conjunction with the power control circuit located on the common circuits board. The power control circuits provide power leveling and protection to the final power amplifier stage of the transmitter. These circuits receive forward and reflected power data from a directional coupler that is electrically located between the harmonic filter and the antenna relay. The transmitter IPA receives a control volage that is controlled by the forward power, VSWR, final PA temperature data, and PA final current. When the control voltage changes, it causes a change in the gain of the first stage of the IPA and, hence, in the rf drive level to the final power amplifier.

*Table 1. Data Contained in Mode Label A (for illustration only)*

| Mode | Control Head Mode | RX Freq. (kHz) | TX Freq. (kHz) | RX Code | TX Code | Dir. Freq. | TOT (Min.) | Sql. | TX PO |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 150270 | 150270 | 1A | 1A | — | 1 | AND | High |
| 2 | 2 | 159920 | 150270 | CSQ | 1A | — | 0.25 | Std | Low |
| 3 | 3 | 159330 | 151190 | 7A | 036 | — | 7.75 | AND | Low |
| 4 | 4 | 172325 | 172325 | 134.8 | 134.8 | — | Off | AND | High |
| 5 | 5 | 151220 | 151220 | 174 | CSQ | — | 1 | Std | High |
| 6 | 6 | 159390 | 159390 | CSQ | CSSQ | — | Off | Std | High |
| 7 | 7 | 168200 | 168200 | CSQ | CSQ | — | Off | Std | High |
| 8 | 8 | 171525 | 171525 | CSQ | CSQ | — | Off | Std | High |

**NOTE**
Label A is supplied with each radio.

## 3.3 *SYNTOR X* MODES OF OPERATION

3.3.1 The mode of a *SYNTOR X* radio is preprogrammed to contain the following operational data:

- receive frequency
- receive coded squelch

} receive channel

- transmit frequency
- transmit coded squelch

} transmit channel

- time-out timer duration
- squelch operation
- channel scan operation
- channel scan frequency list
- transmit output power

} radio control data

Each mode position on the control head has its own receive channel, transmit channel, and radio control data information, some of which may be the same on different modes.

3.3.2 Each *SYNTOR X* high-band radio is provided with a mode label (Table 1) that gives the data associated with the modes that have been preprogrammed into the radio in accordance with the user's requirements. This label (identified as Label A) is located on the inside of the top cover of the radio. However, three labels are provided if the radio is equipped with all the options. Label A (Table 1) is supplied with each radio. Label B (Table 2) is provided only if one of the *Channel Scan* options is ordered. Label C (Table 3) is provided when one of the operator-selectable coded squelch options (W415 or W416) is used. The labels shown in Tables 1, 2, and 3 are for illustrative purposes only.

*Table 2. Data Contained in Mode Label B (for illustration only)*

| Control Head Mode | *Channel Scan* | Internal List | P1 | P2 |
|---|---|---|---|---|
| 1 | On | 7, 8 | 1 | 4 |
| 2 | Off | — | — | — |
| 3 | Off | — | — | — |
| 4 | On | 4, 5, 7, 8 | 1 | 5 |
| 5 | On | 4, 5 | None | None |
| 6 | On | 1, 4, 5 | 6 | None |
| 7 | Off | — | — | — |
| 8 | Off | — | — | — |

**NOTE**
This label is additionally provided for radios equipped with one of the *Channel Scan* options.

*Table 3. Data Contained in Label C (for illustration only)*

| Code | TX | RX |
|---|---|---|
| 1 | 1A | 1A |
| 2 | 7A | CSQ |
| 3 | CSQ | 7A |
| 4 | 036 | 036 |
| 5 | 214.0 | 214.0 |
| 6 | 306 | M1 |
| 7 | M6 | M6 |
| 8 | 142.4 | 142.4 |

**NOTE**
Label C is provided for radios equipped with operator-selectable coded squlech option.

3.3.3 The label illustrated in Table 1 (Label A) shows that the radio is provided with eight modes and that each mode contains more or less different data. For example, mode 1 specifies the following:

- Receive frequency (RX FREQ): 150270 kHz
- Transmit frequency (TX FREQ): 150270 kHz
- Receive code (RX CODE): PL code 1A
- Transmit code (TX CODE): PL code 1A
- Direct frequency (DIR FREQ): none (this is specified only if the repeater/talkaround option is used)
- Time-out timer (TOT): 1 minute
- Opening squelch (SQL): AND
- Transmit power output (TX PO): HIGH.

3.3.4 Mode 1 of label B (Table 2) specifies the following additional data for radios equipped with a *Channel Scan* option:

- *Channel Scan*: ON
- Internal list: modes 7 and 8
- Highest priority mode (P1): mode 1
- Second highest priority mode (P2): mode 4.

3.3.5 Code 1 of label C (Table 3) specifies the following additional data for radios equipped with an operator-selectable coded squelch option:

- Transmit code: PL code 1A
- Receive code: PL code 1A.

3.3.6 The 1-minute time-out-timer duration specified for mode 1 is the standard time-out timer option. However, a radio can be preprogrammed to provide a shorter or longer time-out-timer duration. This additional optional capability provides a range from 15 seconds to 7 minutes and 45 seconds in 15-second increments. Consequently, a specified radio mode can be optinally preprogrammed to provide a time-out-timer duration of, say, 45 seconds.

3.3.7 Squelch operation is specified as standard or "AND". When standard squelch is used, the radio unmutes upon detecting the proper coded squelch, and mutes upon losing the proper coded squelch. Consequently, for standard squelch operation, setting of the SQUELCH control on the control head is not required. When "AND" squelch is used, the radio unmutes upon detecting both the proper coded squelch and channel activity, and mutes upon losing detection of the proper coded squelch. The difference between the two types of squelch is summarized in Table 4. With "AND" squelch, the SQUELCH control on the control head can be used to adjust the squelch to the desired level. In both cases, when the microphone is removed from the hangup box to transmit, the receiver reverts to the carrier squelch mode, thus permitting the user to verify that the channel is clear before transmitting. In this case, the SQUELCH control adjusts the squelch level even if standard squelch is specified.

*Table 4. Standard and "AND" Squelch Operation*

| Squelch Type | Radio Unmutes | Radio Mutes |
|---|---|---|
| STANDARD | Detection of proper coded squelch | Loss of detection of proper coded squelch |
| "AND" | Detection of proper coded squelch *and* channel activity | Loss of detection of proper coded squelch |

3.3.8 When the channel scan is specified as OFF, no further data is entered; however, when the channel scan is specified as ON, a list of non-priority channels follows. This can be followed by a priority-one (highest priority) channel and, possibly, by a priority-two (second highest priority) channel. For example, in mode 1 of Table 2, the channel scan is specified ON and is followed by a non-priority internal list of Modes 7 and 8. The highest-priority (P1) mode is Mode 1 (the selected mode) and the second highest-priority mode is Mode 4. If the highest-priority and the second highest-priority modes are not specified, P1 and P2 are labeled "NONE", as shown in Mode 5 of label B (Table 2). If only the highest-priority mode is specified (as shown for Mode 6 in Table 2), the second highest-priority mode (P2) is labeled "NONE".

3.3.9 In the dual-priority example illustrated in Table 2, Mode 1 is selected. In the absence of channel activity, the radio receiver scans all the modes designated in the internal list, P1, and P2 (i.e., Modes 7, 8, 1, and 4 respectively). When activity is detected on a non-priority mode (Modes 7 or 8), the radio stops scanning all the channels, unmutes the audio on the mode with the activity, but persists in looking for activity on the highest-priority mode (Mode 1) and the second highest-priority mode (Mode 4). This search is analogous to "cutting small holes" in the audio while the receiver is sampling the priority modes. If activity is detected on the second highest-priority mode (Mode 4), this channel takes precedence over the non-priority modes, and the receiever reverts to the second priority mode. Once locked on the second priority channel, the receiver keeps looking for activity on the highest- priority channel (Mode 1); again, the search "cuts small holes" in the audio while the receiver is looking for activity on the highest-priority channel. When activity is detected on the highest-priority channel, the receiver locks on this channel and no further scanning occurs until after activity has ceased on the highest-priority channel.

### 3.4 SELECTABLE TRANSMIT OUTPUT POWER

This option allows the *SYNTOR X* high-band radio to be programmed to provide two different power output levels: 55 watts or 110 watts. Mode Label A, illustrated in Table 1, shows that if Mode 1 is selected, the transmitter will provide a high output; the same table shows that a low power output is provided on Modes 2 and 3. (The high output power level is controlled by POWER SET potentiometer R911, whereas the low output power level is controlled by potentiometer R983.)

### 3.5 OPERATOR-SELECTABLE MULTIPLE CODED SQUELCH

When the *Systems 90•S* operator-selectable multiple coded squelch option is used, the transmit (TX) and receive (RX) codes will be the ones specified in Table 3. For Mode 1, for example, the TX and RX codes are 1A, as shown in Table 3. If this option is turned off, the TX and RX codes will be specified by Mode Label A (Table 1).

## 4. PRIMARY POWER SOURCE

The *SYNTOR X* radio is designed to operate from a negative-ground, 12-volt dc source. However, an optional cable kit allows the radio to operate from positive-ground sources. A built-in floating ground is used by the radio.

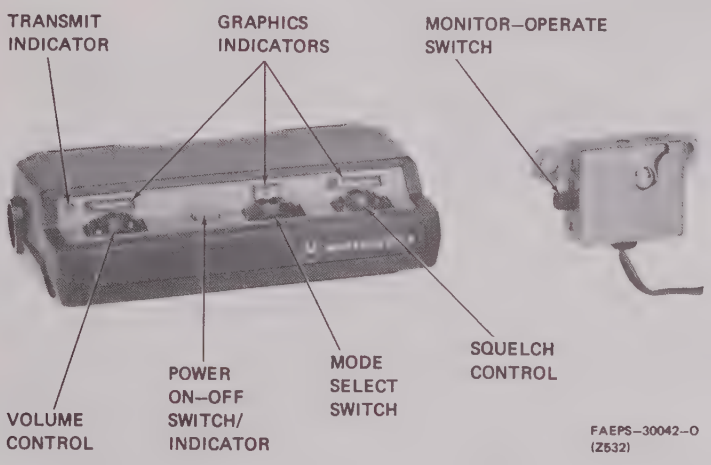
## 5. PHYSICAL CHARACTERISTICS

5.1 The *SYNTOR X* electronic circuits are enclosed in a rugged low-profile housing. One end of the housing contains the antenna connector, lockswitch, main cable connector, and handle. The other end contains the heatsink fins, which provide cooling for the power amplifier circuits. The various radio circuits have been provided with the proper isolation by using partitions and shielding covers. The radio employs an easy-to-snap-on top cover and a bottom cover that is secured to the radio by means of four screws. A mounting tray is also provided with the radio.

5.2 The electronic circuits of the radio are divided into five major subassemblies that can be removed and replaced with ease. The radio employs printed circuit boards that can be plugged together. The TRAC-MODE microprocessor can be electronically "isolated" by following a simple procedure. The radio employs standard Motorola centralized metering arrangement, and requires only three (3) field adjustments, thus further simplifying servicing and replacement of parts.

5.3 The *SYNTOR X* radio occupies 460 cubic inches (7528 cubic centimeters) of space and weighs 22.5 lbs. (10.2 kg).

# OPERATING INSTRUCTIONS




## 1. INTRODUCTION

The *SYNTOR X* control head is equipped with the following controls and indicators:

- rotary VOLUME control
- two-way (up or down) power on-off switch/indicator
- rotary mode select switch (this switch is omitted from single-mode control heads)
- rotary SQUELCH control
- transmit indicator
- graphics indicators associated with the VOLUME, power on-off, and SQUELCH controls

1.2 The microphone hang-up box contains a single two-way up or down) monitor-operate switch.

## 2. TO RECEIVE

Step 1. Place your finger under the control head and push the power on-off switch/indicator upwardly until it locks in position. The graphics indicators light will be visible only in dim ambient light conditions.

Step 2. On multi-mode models, turn the mode select switch to the desired mode.

**NOTE**

Full description of the *SYNTOR X* mode operation is provided in the Description section of this manual.

Step 3. (For PL/DPL models.) With the microphone attached to its hang-up box, set the monitor-operate switch to the lower position; only the PL/DPL-encoded signals will be heard now. Set the monitor-operate switch to the upper position; now all the on-frequency signals will be heard.

Step 4. Remove the microphone from its hang-up box; now all the on-frequency signals will be heard irrespective of the position in which the monitor-operate switch is placed.

Step 5. Turn the SQUELCH control fully counterclockwise.

Step 6. Turn the VOLUME control clockwise.

Step 7. Slowly turn the SQUELCH control clockwise (opposite to that in Step 5) until the noise is just squelched (i.e., it cannot be heard).

Step 8. Set the VOLUME control to the position that provides the desired listening level of an incoming signal.

Step 9. If transmission is desired, proceed to the next procedure. (Power can be turned off by pushing the power on-off switch/indicator in a downward movement until it locks.)

## 3. TO TRANSMIT

Step 1. If the equipment power has been turned off, it can be turned on by repeating Step 1 of the "TO RECEIVE" procedure.

Step 2. Turn on the vehicle ignition switch, if required. It is recommended that the engine be kept running during transmission to avoid draining the battery.

Step 3. Repeat Steps 2 through 8 provided under the "TO RECEIVE" procedure, if this has not already been done.

Step 4. Remove the microphone from its hang-up box; now all the on-frequency signals will be heard. After verifying that the channel is clear, depress the microphone PTT switch; the transmit indicator will light.

Step 5. Start transmission by first identifying yourself and the mobile unit or station being called. (For best results, a distance of at least one inch should be maintained between the microphone and the speaker's lips.)

Step 6. At the end of transmission, release the PTT switch and listen to the message.

Step 7. When no more transmission or reception is desired, turn the power off by pushing the power on-off switch/indicator in a downward movement. All indicators will go off.

## 4. *SYNTOR X* MODES

4.1 The *SYNTOR X* modes are preprogrammed into the radio memory at the factory in accordance with the user's requirements. A *SYNTOR X* high-band radio can be programmed with four, eight, sixteen, or thirty-two modes. For example, a mode (depending on the options used) may be programmed to contain the following data:

- Mode: 1
- Receive frequency: 150270 kHz
- Transmit frequency: 150270 kHz
- Receive code: PL code 1A
- Transmit code: PL code 1A
- Time-out timer: 1 minute
- Opening squelch: AND
- Transmit power output: high
- *Channel Scan*: ON
- Internal list: modes 7 and 8
- Highest priority mode: mode 1
- Second highest-priority mode: mode 4.

4.2 For further information on the *SYNTOR X* modes, refer to the Description section in this manual.

## 1. SERVICE

Should you wish to purchase a service contract for your Motorola equipment, contact your Motorola Service Representative, or write to:

National Service Manager
Motorola Communications Group
1301 E. Algonquin Rd.
Schaumburg, Illinois 60196

## 2. FCC REQUIREMENTS

2.1 You are required by the FCC to obtain a station license for your radio equipment before transmitting. No operating license or permit is required. The station licensee is responsible for ensuring that the transmitter power, frequency, and deviation are within the maximum limits allowed by the station license.

2.2 The FCC requires that these checks and any transmitter adjustments be performed only by persons holding a valid 1st or 2nd class commercial radiotelephone operators license or by personnel working under their immediate supervision.

2.3 The power input to the final radio frequency stage shall not exceed the maximum figure specified on the current station authorization. This power input shall be measured and the results recorded:

- when the transmitter is initially installed.
- when any change is made in the transmitter which may increase the power input.
- at intervals not to exceed one year.

2.4 Frequency and deviation of a transmitter must be checked:

- when it is initially installed.
- when any change is made in the transmitter which may affect the carrier frequency or modulation characteristics.
- at intervals not to exceed one year.

## 3. PRE-INSTALLATION TESTS

Although the equipment has been accurately aligned at the factory, it is possible that mishandling in transit may have disturbed some of the adjustments. In addition, FCC regulations require transmitter frequency and deviation to be checked at installation. It is essential therefore, that a pre-operational check be made to assure proper operation. For complete checkout, follow the sequence of tests presented below. Complete information for performing the tests are fully outlined in the System Maintenance and Adjustments sections of this instruction manual.

Step 1. Check the highest transmit frequency (highest repeater frequency) and adjust as required. This will also correct the receive frequency errors caused by the reference oscillator.

Step 2. Measure the transmitter power output at the highest transmit frequency on modes programmed for both high-power operation and low-power operation, and make adjustments, as required.

Step 3. Measure the transmitter deviation at the highest transmit frequency (highest repeater frequency) and make the necessary adjustments as required.

Step 4. Measure the transmit frequency.

Step 5. Measure the receive frequency.

Step 6. Measure the 20 dB quieting signal level.

Step 7. Measure the PL or DPL sensitivity in PL/DPL models.

**NOTE**
Repeat Steps 4 through 7 for each mode.

Step 8. Check the antenna VSWR after installing it in the vehicle.

## 4. INSTALLATION PLANNING

Refer to the installation planning diagram (Figure 1) which provides information on the antenna location, operator's controls, radio set location, control and power cable routing, transmitter control power lead, receiver control power lead, primary power connections, and other accessories.

**WARNING**

For vehicles equipped with electronic anti-skid braking systems, refer to "Anti-Skid Braking Precautions", Motorola publication number 68P81109E34. This document is available free of charge.

### 4.1 ANTENNA LOCATION

The best location for the antenna is at the center of the vehicle roof. A good alternate location is at the center of the trunk lid. Be sure that the antenna cable can be acceptably routed to the radio set before mounting the antenna. Refer to the antenna instruction manual for details.

**NOTE**

Do not alter the whip length of the antenna or the length of the coaxial cable, since these changes can affect the broadband performance of the antenna.

**CAUTION**

Antennas must be installed at least two feet (0.6 meter) from vehicle operators and passengers unless shielded by a metallic surface.

### 4.2 RADIO SET LOCATION

In most vehicles, the best location for the radio unit is the floor of the trunk compartment. When considering location make certain that the radio set is protected from dirt and moisture and that there is sufficient space around the radio to allow adequate cooling and removal of the unit.

### 4.3 OPERATOR'S CONTROLS

Recommended mounting surfaces for the control head, microphone hangup box and speaker include under the dashboard, on the transmission hump, or on the center console. In addition, the speaker may be mounted on the firewall. Adjustable trunnions are provided for the mounting of the control head and the speaker which accommodate a large number of mounting positions. Holes for mounting the hangup box or clip are also provided on the under side of the control head. The installation must not interfere with the operation of the vehicle or its accessories, nor disturb passenger seating or leg space. The control head and the microphone hangup box must be within convenient reach of the user(s).

### 4.4 CONTROL AND POWER CABLE ROUTING

Many vehicles are equipped with wire troughs in the door sills. If the vehicle has this feature, use it to provide maximum protection for the cable and to simplify the cable installation. In vehicles without wiring troughs, the control and power cables must be routed where they are protected from pinching, sharp edges, and crushing. One suggested route is along one side of the drive shaft hump under the carpet. Be sure grommets are used whenever the cable must pass through a hole in a metal panel.

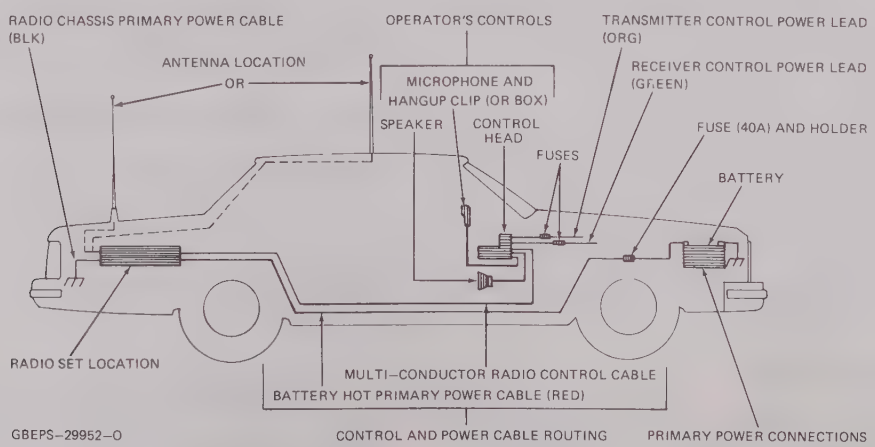



*Figure 1. Installation Planning*

**NOTE**

The alternator whine performance may be degraded if the unused portion of the control cable is coiled and placed directly on top of the radio.

### 4.5 PRIMARY POWER CONNECTIONS (RED)

The best power connection point for the battery hot primary power lead is at the hot battery terminal. Points connected directly to the battery terminal with sufficient current-handling capabilities may also be used. Make certain that the point chosen remains close to 13.6 volts; some systems switch to a higher-than-normal voltage during starting.

### 4.6 TRANSMITTER CONTROL POWER LEAD (ORANGE)

This lead may be connected to the ignition switch (recommended) or directly to a battery hot supply. Refer to the cable connections diagram.

### 4.7 RECEIVER CONTROL POWER LEAD (GREEN)

This lead may be connected to a battery hot supply (recommended) or to the ignition switch. Refer to the cable connections diagram.

### 4.8 RADIO CHASSIS PRIMARY POWER CABLE (BLACK)

The radio set chassis primary power cable should be connected to a good ground point on the vehicle chassis.

## 5. CABLE ROUTING

(Refer to Figures 1 and 2.)

**CAUTION**

In positive ground vehicles, a positive ground cable kit must be used. A negative ground cable kit can be converted for positive ground operation if required.

**CAUTION**

Before the cable is routed (after unpacking) four leads must be removed from the black connector block that connects to the control head. Remove the green and orange fused power leads and the two PL/DPL leads from the hangup switch box.

Step 1. Determine the position that the radio set will occupy in the trunk compartment and leave enough slack cable to permit the plug to be easily connected or disconnected from the radio set.

Step 2. Work from the trunk space forward. In some cars there is enough room below the fiberboard trunk partition to admit the cables. If this is not the case, make an opening through the partition. Remove the back seat.

Step 3. The control head end of the multi-conductor cable kit is terminated in one black and one blue connector housing. If the leads must be removed from the connector housing to permit passage of the cable, use the following procedures:

- Each cable kit has a contact removal tool (Motorola part no. 66C84699B01) taped to it. Slide the small end of the tool into the front of the individual contact position so that the tab of the female contact is pushed up and the contact may be removed from the housing by carefully pulling it out with the wire. Repeat this operation until all wires are removed from each connector housing.

- Tape the female contacts into a small bundle. Pass it and the long red power cable into the passenger compartment. After reaching the control head position reinsert the female contacts into the proper contact positions in the connector housings.

Step 4. Pull the cables into the back seat area, under the floor mats and front seat, out to the top of the floor mat under the dash. Where no specific channel is provided, route the cables under the floor mat along the side of the drive-shaft tunnel. Pull the control head end of the mutli-conductor cable to the approximate location of the control head. Route the red power cable into the engine compartment through any convenient hole already in the firewall. If necessary, make a 1/2-inch diameter hole elsewhere in the firewall, install the supplied grommet, and route the cable through the grommet.

Step 5. Pull the red power cable into the engine compartment. A cable fuse kit has been supplied with a ring tongue lug on one end and an in-line fuseholder on the other. A small section of heat-shrinkable tubing is supplied with each cable. Any excess red cable length should be trimmed at this time. Slide the heat-shrinkable tubing over the red power lead from the radio. Slide the strapped portion of the red cable into the end of the in-line fuseholder and crimp the joint using a Burndy Model Y10B (indent "U" crimp). If this tool is not available, soldering is required.

Step 6. Slide the heat-shrinkable tubing over the connection and shrink the tubing using a Motorola Model ST697 Heat Gun or equivalent heated air source. Remove the fuse from the fuseholder and reconnect the holder. Fasten the ring-tongue lug on the end of the cable to the battery's ungrounded terminal or to some point directly connected to the ungrounded terminal of the battery (such as the starter solenoid). Move the in-line fuseholder to a convenient location on one of the sheet metal parts of the engine compartment. Center punch and drill a 9/64" (.140") hole through the

mounting surface. Then use the supplied #10-16-3/4" self-tapping sheet metal screw to mount the bracket. Do not replace the fuse until the entire installation of the radio set is complete.

Step 7. The control head power cable kit contains two separate wires, each equipped with an inline fuse. The orange wire is 69 inches long and the green wire is 100 inches long. Taped to the lugless end of each cable are a crimp-on type ring tongue lug and a crimp-on type spade lug. The spade lug allows connection to hot leads at the fuse block of the vehicle and the ring tongue lug permits attachment to screws of terminals. Determine from Table 1 which radio functions are to be switched through the vehicle ignition switch. A typical hookup provides for ignition switch control of the transmitter function only, thus permitting the receiver to operate whenever the radio set is turned on. In this case, the orange wire is connected to the accessory terminal of the ignition switch and the green wire is connected directly to the ungrounded terminal of the battery or starter solenoid.

**CAUTION**

Do NOT connect either lead to the ungrounded terminal of the battery at this time.

Step 8. If either wire is to be connected in the engine compartment, pass the lugless end of the wire through the same firewall hole that the red power cable uses, trim to length and crimp on the ring lug. If directed to a point within the passenger compartment, route cable to the point, leaving some extra length, and trim. Strip and crimp on either the spade or the ring tongue lug whichever is required. As an extra precaution the wire and lug may be soldered after crimping.

Step 9. Do not dress the wires at this time, but go to the next procedure.

## 6. RADIO INSTALLATION

(Refer to Figures 3 and 4.)

**WARNING**

For vehicles equipped with electronic anti-skid braking systems, refer to "Anti-Skid Braking Precautions", Motorola publication number 68P81109E34. This document is available free of charge.

Step 1. Choose a location where the mounting screws are not directly above the gas tank, gasoline, or other vital parts. The mounting tray of the radio set must be mounted permanently to a flat surface using four mounting holes or to an uneven surface using the alternate three point mounting. (The four point mounting is strongly recommended for installation in vehicles subject to extreme vibrations.) The raised shelf in some car trunk compartments makes a good mounting place. Place the radio at one side to allow space for luggage. Leave at least three inches in front of the radio set, so that the handle can be opened and the radio assembly can be removed from the mounting tray. The radio must be located so that the black ground lead in the trunk can reach a good chassis ground point in the trunk. When the final position is determined, unlock the radio, open the hadle and lift the radio assembly away from the mounting tray (pull forward and upward to release the radio assembly). The mounting tray can be used as a template to mark the location for drilling the four mounting holes in the trunk floor. Use a #11 drill (.191"). Mount the mounting tray as illustrated in Figures 3 and 4.

Step 2. When the radio set is securely mounted to the trunk floor in some vehicles, the front panel will be pressing against the floor or floor cushioning. Also, in some vehicles where it is necessary to mount the radio set directly over the gas tank, the mounting screws may penetrate the tank (always make a preliminary check to see how far the screws will extend below the trunk floor). If either condition exists, insert one of the thick spacer washers between the bottom of the mounting tray and the thin spacer washer, at each of the four mounting holes. The washers help to keep the radio set level, especially when the floor is covered with a "spongy" mat such as soft rubber. Replace the radio assembly by sliding the radio onto the tray at about the halfway point. Push straight back until the tray tabs enter the two window areas on the radio front and engage the handle tabs. Close by pushing the handle until it locks. The handle locks the radio to the mounting tray and conceals the top cover release button. Push the multi-conductor plug onto the male connector and rotate the thumbscrew clockwise to fully seat the connector. Reverse the procedure for removing the radio.

Step 3. Connect the black ground cable lug to a convenient location on the trunk floor. Thoroughly clean the

*Table 1. Radio Functions Connections*

| Conductor | Green | Orange | Green | Orange | Green | Orange |
|---|---|---|---|---|---|---|
| Connected to battery | • | • | • | | | |
| Connected to ignition switch | | | | • | Note 1 | • |
| Ignition switch controls | No switch control | | Xmtr switch controlled | | Complete radio switch controlled | |
| In any application, trim and strip wires. Crimp on ring lug for battery connections. For ignition switch connections, crimp on ring or spade lug (whichever is required). | | | | | | |

Note 1: In cases where alternator whine or other interference is a problem, the green lead can be isolated with a relay (Motorola part no. 59-813674).

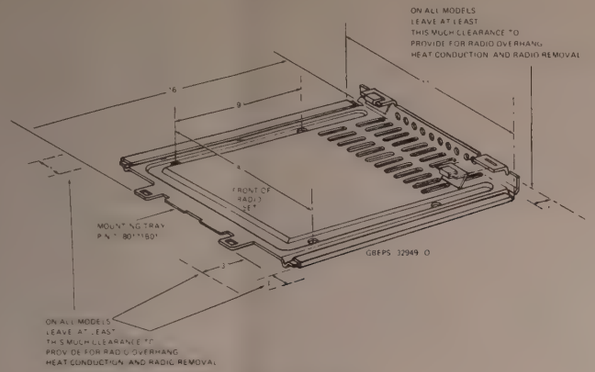



*Figure 3. Mounting Tray*

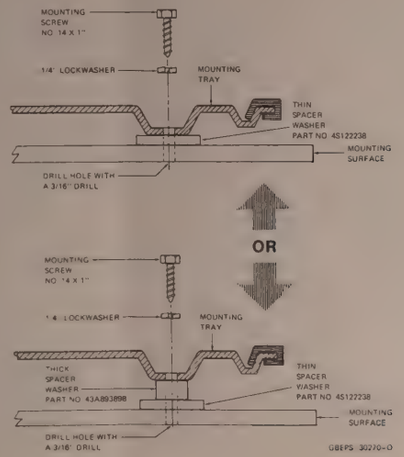
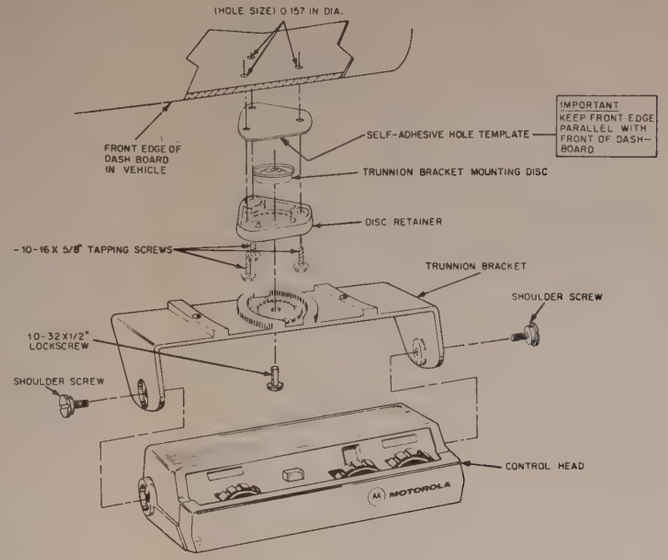



*Figure 4. Mounting Tray Installation Detail*




**OR**

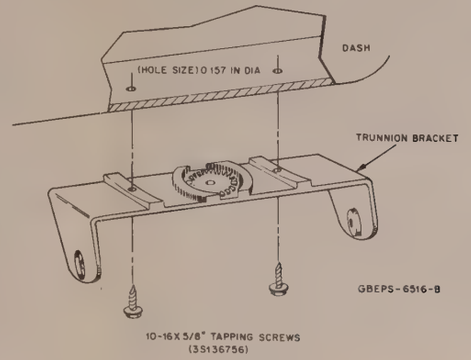
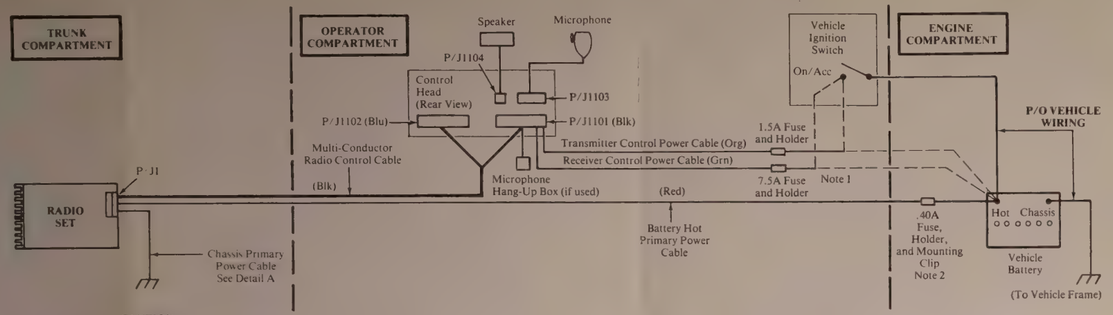
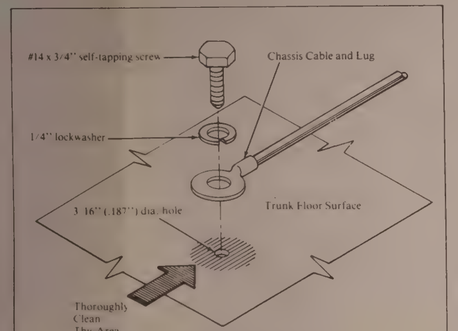


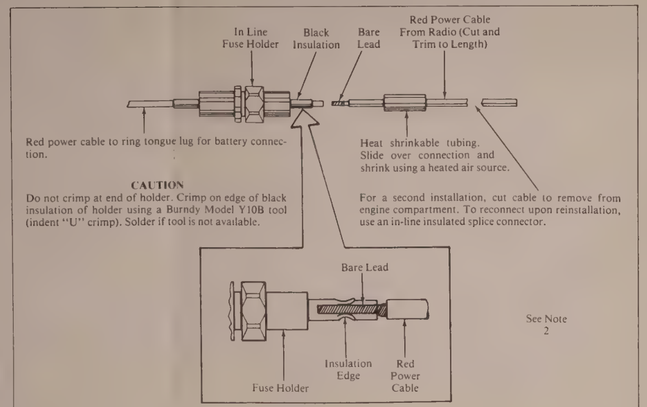

*Figure 5. Control Head Installation*




**CAUTION**
A good chassis connection via the black primary power cable is essential for radio operation and to prevent damage to the radio and cable kit. Connection to the vehicle frame is desirable




**DETAIL A**
**RADIO SET CHASSIS CONNECTION**


In Line Fuse Holder
Black Insulation
Bare Lead
Red Power Cable From Radio (Cut and Trim to Length)
Red power cable to ring tongue lug for battery connection.
CAUTION
Do not crimp at end of holder. Crimp on edge of black insulation of holder using a Burndy Model Y10B tool (indent "U" crimp). Solder if tool is not available.
Heat shrinkable tubing. Slide over connection and shrink using a heated air source.
For a second installation, cut cable to remove from engine compartment. To reconnect upon reinstallation, use an in-line insulated splice connector.
Bare Lead
Insulation Edge
Red Power Cable
Fuse Holder
See Note 2

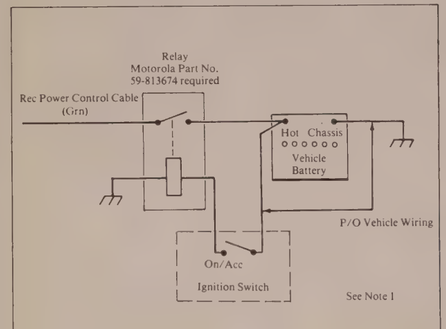
**DETAIL B**
**BATTERY HOT IN-LINE FUSE INSTALLATION**

**NOTES:**

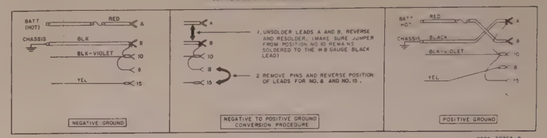
1. The transmitter power control cable (ORG) and the receiver power control cable (GRN) may be connected to the vehicle battery or to the ignition switch. The recommended configuration of these cables connects the receiver control cable (GRN) directly to the battery and the transmitter control cable to the ignition switch (at the ON/ACC terminal). In this configuration, the receiver is operable whenever the control head is turned on but the transmitter is operable only when the ignition switch is turned on (as well as the control head). If both cables are connected directly to the battery, the entire radio is operable (under control of the control head). If both cables are connected to the ignition switch, the radio is operable only when the ignition switch is turned on. In this configuration, alternator whine and other noise problems may occur in the receiver section. If this is the case, the receiver control cable may be isolated with a relay (Motorola number 59-813674 or equivalent) as shown in Detail C.

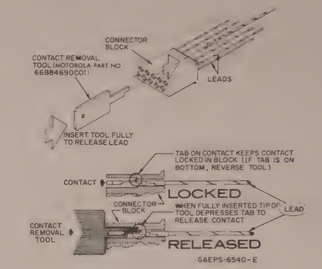
2. The radio battery hot primary power cable is supplied as two pieces, a red cable which is part of the radio control cable kit and another red cable with an in-line fuse on one end and a ring tongue lug on the other. After routing the radio power cable from the radio connector to the engine compartment, these cables are spliced as shown in Detail B. Refer to the cable routing procedure for further details.

GCEPS-30267-A




**DETAIL C**
**RECEIVER POWER CONTROL ISOLATION**





CONNECTOR BLOCK
CONTACT REMOVAL TOOL (MOTOROLA PART NO 6688469C01)
LEADS
INSERT TOOL FULLY TO RELEASE LEAD
TAB ON CONTACT KEEPS CONTACT LOCKED IN BLOCK. (IF TAB IS ON BOTTOM, REVERSE TOOL)
CONTACT
LOCKED
CONNECTOR BLOCK
WHEN FULLY INSERTED TIP OF TOOL DEPRESSES TAB TO RELEASE CONTACT
LEAD
CONTACT REMOVAL TOOL
RELEASED
GAEPS-6540-E

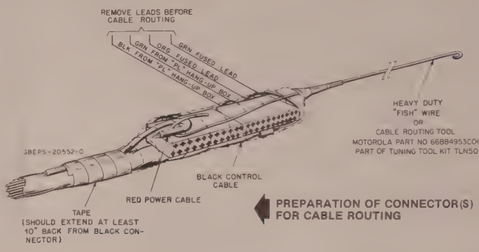

REMOVE LEADS BEFORE CABLE ROUTING
ORG FUSED LEAD
GRN FUSED LEAD
GRN FROM "A" HARNESS BOX
BLK FROM "C" HARNESS BOX
JBEPS-20552-O
HEAVY DUTY "FISH" WIRE OR CABLE ROUTING TOOL MOTOROLA PART NO 6688495301 PART OF TUNING TOOL KIT TLN5048A
BLACK CONTROL CABLE
RED POWER CABLE
TAPE (SHOULD EXTEND AT LEAST 10" BACK FROM BLACK CONNECTOR)
PREPARATION OF CONNECTOR(S) FOR CABLE ROUTING

*Figure 2. Cable Routing Details*

trunk floor surface before proceeding. Center punch and drill a 3/16" (.187") hole through the mounting surface. Use the supplied #14 x 3/4" self-tapping screw and 1/4" lockwasher to mount the cable lug.

**CAUTION**

A good ground connection of the black cable is essential for radio operation and to prevent damage to the radio and cable kit. Grounding to the vehicle frame is desirable. On some late-model automobiles the ground connection between the vehicle chassis and engine block is inadequate for good mobile radio operation. *DO NOT* compensate for this problem by connecting the radio set ground directly to the battery. Connect a flexible metal ground strap between the engine block and a vehicle chassis point common to the radio set ground. Be sure the strap is heavy enough to carry maximum transmitter supply current.

Step 4. All cables (including the antenna lead-in) should be dressed out of the way as much as possible to prevent damage and the radio heatsink should be placed to have the largest available supply of air possible for cooling.

## 7. CONTROL HEAD INSTALLATION

### 7.1 GENERAL

The control head must be installed within the reach of the operator. Pull more control cable into the area, if necessary. At this time, insert the female contacts from the green and orange fused wires into the proper position in the black connector housing. Be sure that all wires are clear of the instrument panel where holes are to be drilled.

### 7.2 INSTALLATION PROCEDURE
(Refer to Figure 5.)

Step 1. Determine the location for mounting the control head.

Step 2. Remove the trunnion bracket and retainer assembly from the control head by removing the two trunnion side screws.

**CAUTION**

Care must be taken in removing the trunnion bracket from the control head. After removing the side screws from the trunnion bracket, spread the bracket slightly to prevent damage to the circular friction action between the cup on the control head and the clutch facing on the bracket.

Step 3. Disassemble the retainer and breakaway disc assembly from the trunnion bracket by using a 5/16" nut driver to remove the #10-32 x 1/2" lockscrew.

Step 4. Remove the tapping screws and lockwashers from the control head retainer. Discard the paper retainers.

Step 5. Remove the backing from the self-adhesive mounting template and fasten the template at the location where the control head is to be mounted.

**NOTE**

This template locates the mounting holes for drilling and should be left in place to show the re-assembly of the trunnion bracket if the installation is changed at a later date.

Step 6. Center punch and drill two 0.157" (#22 drill) holes at the position located on the template.

Step 7. Mount the control head retainer and breakaway disc assembly with the supplied hardware (two #10 x 5/8" tapping screws and #10 lockwashers) using a 5/16" nut driver.

Step 8. Mount the trunnion bracket to the control head retainer assembly using the #10-32 x 1/2" lockscrew removed in Step 3.

**NOTE**

Before tightening the lockscrew, rotate the trunnion bracket to the desired horizontal position; then tighten the lockscrew.

Step 9. Insert the connector housings into the proper locations on the back of the control head. Now connect the control cable "S" hook to the proper hole in the cable strain relief bracket on the rear of the control head.

Step 10. Reassemble the control head to the trunnion bracket using caution as advised in Step 2.

**NOTE**

Before tightening the two trunnion side screws, rotate the control head into the desired vertical position.

### 7.3 BULB REPLACEMENT

Pilot bulbs can be replaced from the rear of the control head. Merely rotate the socket counterclockwise 45° and withdraw from the circuit board. Use the fingers to remove the wedge-type bulb by pulling straight out of the socket.

## 8. MICROPHONE INSTALLATION

### 8.1 GENERAL

The microphone bracket must be within a comfortable arm's reach of the operator. Measure this

distance before actually mounting the microphone bracket or the PL/DPL hangup switch box. Since both the bracket and hangup switch box have a positive detent action, the microphone can be mounted in almost any position. Mounting the bracket or hangup box to the bottom of the control head will provide a breakaway feature for the microphone also. After installation, connect the microphone plug to the receptacle on the control head. Make sure that the clip on the control head firmly engages the plug. Connect the microphone cable "S" hook to the proper hole in the strain relief clip on the rear of the control head.

8.2 INSTALLATION PROCEDURE
(Refer to Figure 6.)

Step 1. Remove the hangup clip from its taped position on the microphone.

Step 2. Remove the two paper retainers and screws from the clip.

Step 3. Determine the location for installation.

Step 4. Using the clip as a template, mark the location of the two mounting holes.

Step 5. Center punch and drill a 0.144" diameter hole at each location.

Step 6. Mount the clip securely using the supplied screws.

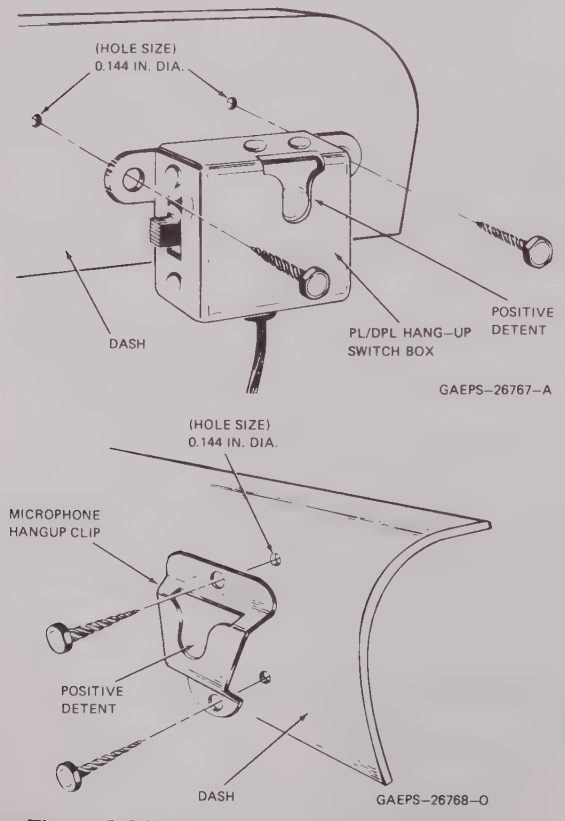



*Figure 6. Microphone Accessory Installation*

## 9. MICROPHONE HANGUP SWITCH BOX INSTALLATION

9.1 GENERAL (*DIGITAL PRIVATE-LINE* AND TONE *PRIVATE-LINE* MODELS ONLY)

The hangup box provides a PL/DPL disable switch as well as an automatic disable function when the microphone is removed. The hangup box has a positive detent action that permits it to retain the microphone regardless of the mounting position. The positive detent action and the fact that the hangup box requires no external grounding of the housing permits the hangup box to be mounted anywhere, in any attitude, that is convenient and permits the two-circuit connector cable to reach the control head.

9.2 INSTALLATION PROCEDURE
(Refer to Figure 6.)

Step 1. Remove the paper retainers and screws from the mounting flanges on the hangup box.

Step 2. Determine the mounting location and using the hangup box as a template, mark the location for both screw holes.

Step 3. Center punch and drill a 0.144" diameter hole at each location.

Step 4. Securely fasten the hangup box to the mounting surface with the supplied screws.

Step 5. Connect the hangup box to the control head. Tape or tie up the extra cable.

## 10. HANDSET HANGUP SWITCH BOX (OPTIONAL) INSTALLATION

The optional handset hangup switch box can be mounted either with a trunnion bracket or flush against a flat surface.

10.1 TRUNNION MOUNT

Step 1. Remove the three protective caps and screws from the trunnion bracket.

Step 2. Place a handset in the hangup unit.

Step 3. Choose a location which offers both operator convenience and allows the handset to clear the floor or transmission tunnel.

Step 4. Lightly mark this location.

Step 5. Remove the handset from the hangup unit.

Step 6. Loosen the two screws securing the hangup unit to the trunnion bracket and remove the trunnion bracket.

Step 7. Using the trunnion bracket as a template, mark the location of the three mounting holes.

Step 8. Center punch and drill a 0.175'' diameter hole at each location.

Step 9. Mount the trunnion bracket using the screws supplied.

Step 10. Reinstall the hangup unit in the trunnion bracket and tighten the two screws.

Step 11. Remove the escutcheon backing and press the escutcheon firmly into place.

Step 12. Connect the hangup box wires to the black connector (P1101) and the blue connector (P1102).

10.2 FLUSH MOUNTING

Step 1. Remove the trunnion bracket, two screws, and two flat washers. Retain this hardware for future use.

Step 2. Place a handset in the hangup unit.

Step 3. Select a location which affords operator convenience and allows the handset to clear the floor or transmission tunnel.

Step 4. Use the hangup unit as a template and mark the location of the two holes to be drilled.

Step 5. Remove the handset from the hangup unit.

Step 6. Lay the unit aside. Center punch and drill a 0.128'' diameter hole at each location.

Step 7. Secure the hangup unit to the surface with two 1-3/4'' sheet metal screws provided.

**NOTE**

Dress the cable through the elongated hole before tightening the sheet metal screws.

Step 8. Remove the escutcheon backing and press the escutcheon firmly into place.

Step 9. Connect the hangup box wires to the black connector and blue connector.

## 11. SPEAKER INSTALLATION

11.1 GENERAL

The speaker kit includes a trunnion bracket, hanger bracket, and wall mount bracket, which permits the speaker to be mounted in a variety of ways. The trunnion bracket provides a large variety of permanent mountings (dashboard and accessible firewall areas) for the speaker whlile permitting it to be tilted or angled for best results. The hanger bracket (already attached to the speaker) alone permits temporary mounting on projections such as automobile windows, etc. In this case, the trunnion bracket must be removed. The wall mount bracket can be used for permanent mountings if the trunnion bracket is too large to fit in some inaccessible areas. In this case, the trunnion bracket is removed and the speaker is attached to the wall mount bracket by the hanger bracket.

11.2 INSTALLATION USING TRUNNION BRACKET
(Refer to Figure 7.)

Step 1. Remove the trunnion bracket by loosening the two wing screws.

Step 2. Remove the three paper retainers and screws from the trunnion bracket.

Step 3. Remove the wall mount bracket from its taped position on the hanger bracket (retain for future use).

Step 4. Determine the location for installation. If space limitations require the removal of the hanger bracket, remove the Phillips head screw and slide the bracket out of the speaker housing (the speaker housing does not require disassembly to remove the hanger bracket).

Step 5. Using the trunnion bracket as a template, mark the location of the three desired mounting holes.

Step 6. Center punch and drill a 0.101'' (#38 drill) diameter hole at each location.

Step 7. Mount the trunnion bracket using the supplied screws.

Step 8. Remount the speaker into the trunnion bracket and tighten the two wing-screws.

Step 9. Plug the speaker lead into the control head making sure that the plug is solidly seated.

Step 10. Tie up surplus speaker lead cable.

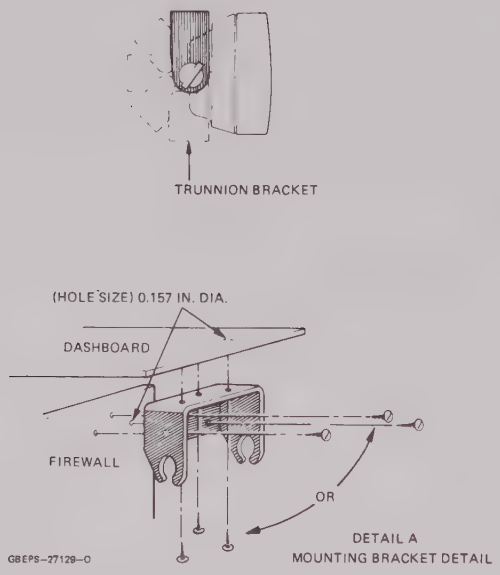
11.3 INSTALLATION USING WALL MOUNT BRACKET
(Refer to Figure 7.)

Step 1. Remove the wall mount bracket from its taped position on the hanger bracket.

Step 2. Remove the trunnion bracket and trunnion wing-screws (retain for future use).

Step 3. Remove the two paper retainers and screws from the wall mount bracket.

**STANDARD MOUNTING BRACKET**




**OPTIONAL WINDOW/WALL MOUNTING BRACKET**

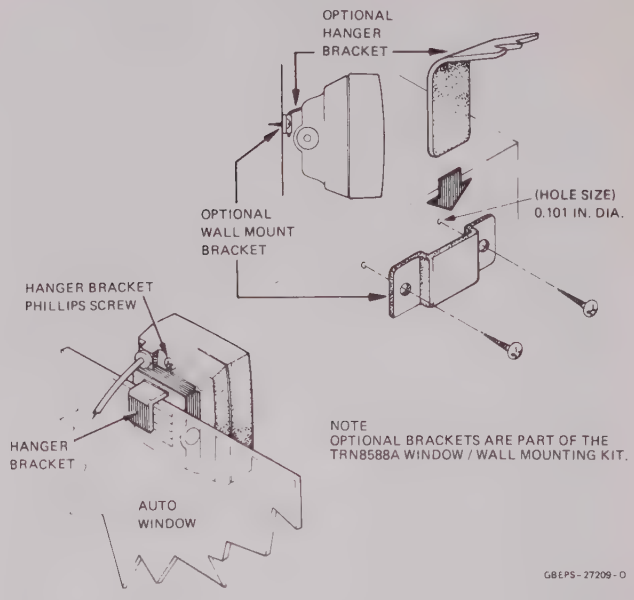



*Figure 7. Speaker Installation Detail*

Step 4. Determine the location for installation.

Step 5. Using the bracket as a template, mark the location for the screws.

Step 6. Center punch and drill a 0.101" (#38 drill) diameter hole at both locations.

Step 7. Mount the wall mount bracket to the surface with the supplied screws.

Step 8. Firmly seat the hanger bracket (attached to the speaker) in the wall mount bracket.

Step 9. Plug the speaker lead into the control head making sure that the plug is solidly seated.

Step 10. Tie up surplus speaker lead cable.

## 12. POWER CONNECTIONS

(Refer to Figures 1 and 2.)

12.1 Replace the fuse in the in-line fuseholder of the red power cable coming from the radio in the trunk. Also connect the green (and/or orange) fused wire(s) coming from the control head to the ungrounded terminal (or source) of the battery.

12.2 Pull all excess cabling into the trunk. Clamp the cables to the vehicle body or chassis using the cable clamps supplied. To secure the clamps four tapping screws (#8-3/8") and four lockwashers (#1/4) are used. A 1/8" (0.125") hole is needed for the tapping screws. Make certain that all in-line fuses are installed.

## 13. ANTENNA INSTALLATION

(Refer to Figure 1.)

A diagram and complete installation instructions are supplied with each antenna ordered. Refer to these installation instructions for all information pertaining to the antenna.

## 14. CONCLUSION OF INSTALLATION

14.1 Make certain that the control head and mic PTT switches are off. Replace the 40A fuse in the red primary power cable in-line holder. Replace the 1.5A fuse in the orange cable in-line holder. Replace the 7.5A fuse in the green cable in-line holder.

14.2 Turn the radio on at the control head and verify proper operation of all controls and indicators. (Radio operation in some installations requires the turning on of the vehicle ignition. See Table 1.) Perform a complete operational check of the radio.

**NOTE**

If alternator or other noise is present in the received signal or in the transmission, refer to "Reducing Noise Interference in Mobile Two-Way Radio Installations", Motorola publication number 68P81109E33. This document is available free of charge.

14.3 Dress the control and power cables out of the way to prevent damage (pull any excess cable into the trunk area) and secure them with the supplied clamps and screws where necessary. Replace the rear seat if it had been removed in the cable routing procedure.

# GENERAL MAINTENANCE/ TROUBLESHOOTING

## 1. RECOMMENDED TEST EQUIPMENT FOR *SYNTOR X* RADIO SERVICING

| General Type | Application | Recommended Model | Minimum Specifications |
|---|---|---|---|
| AC-DC VOM | DC voltage measurements, general | Motorola T1009A | Measurement range: 0-15 V dc<br>Sensitivity: 20,000 ohms/volt |
| DC Multimeter | DC voltage readings requiring a high input resistance meter | Motorola S1063B | Measurement range: 0-15 V dc<br>Input resistance: 11 megohms |
| AC Voltmeter | Audio voltage measurements | Motorola S1053C | Measurement range: 0-1 mV ac<br>Input resistance: 1 megohm |
| RF Voltmeter | RF voltage measurements | Motorola S1339 | Measurement range: 100 uV-3 V from 1 MHz-512 MHz<br>Inputs: 50 ohm and high impedance |
| Oscilloscope, Dual-Trace | Waveform observation | Motorola R1004A | Vertical sensitivity: 5 mV-10 V/division<br>Horizontal time base: 0.2 usec.-0.5 sec/divison |
| RF Wattmeter | Transmitter output power measurement | Motorola S1350 with appropriate element and T1013 RF Dummy Load. | Measurement range: 0-250 watts |
| Frequency Meter | Transmitter frequency measurement | Model R1200 Service Monitor with high stability oscillator (X suffix) option. Frequency calibration recommended every 6 months or less. | Measurement range: 134-174 MHz<br>Frequency resolution: 10 Hz |
| Deviation Meter | Transmitter modulation deviation measurement | Motorola R1200 Service Monitor with SLN6350 Deviaton Meter and SLN6381 Audio Frequency Synthesizer *(audio synthesizer required only for DPL radios).* | Measurement range: 0-10 kHz deviation<br>Frequency range: 134-174 MHz |
| RF Signal Generator | Receiver alignment and troubleshooting | Motorola R1200 Service Monitor with attenuator | Frequency range: 134-174 MHz<br>Output Level: 0.1 uV-100,000 uV<br>Must be capable of at least ±3 kHz deviation when modulated by 1 kHz tone. |
| Audio Signal Generator | Audio circuit troubleshooting | Motorola S1067B | Frequency range: 20 Hz-20 kHz<br>Output level: 50 mV-1 V |
| ■Test Memory Module | Verify microcomputer operation | Motorola HLN1074A | |
| ■Logic Probe | Check Various Digital Devices | Motorola RTL-4014 | |
| PL Tone Generator* | Tone-coded *Private-Line* decoder troubleshooting | Motorola S1333B | Frequency range: 10 Hz-9999 Hz<br>Output level: 0-3 V rms |
| ■DPL Test Set** | *Digital Private-Line* encoder-decoder troubleshooting | Motorola SLN6413A | |
| Radio Test Set | Meter readings at circuit metering points for alignment and troubleshooting | Motorola S1056 Portable Test Set with a TEK-37 or TEK-37A Test Set Adapter or a Motorola TEK-5 Meter Panel with a TEK-40 Cable. | |

## 1. RECOMMENDED TEST EQUIPMENT FOR *SYNTOR X* RADIO SERVICING (Cont'd.)

| | | | |
|---|---|---|---|
| ■Tuning Tool Kit | Receiver and transmitter alignment | Motorola HLN4262A | |
| ■DC Power Supply | DC power for shop service | Motorola R1011AA | 1-20 V dc<br>0-40 A |

*Required for tone-coded *Private-Line* models only

**Required for *Digital Private-Line* models only

**NOTE**

All the test equipment listed above, with the exception of those marked with (■), can be replaced with the Motorola R2001 System Analyzer.

**CAUTION**

In positive ground systems the case of the TEK-5 Meter Panel and portions of the S1056B Portable Test Set are hot with respect to the vehicle chassis due to the nature of the positive ground installations. Take necessary precautions that the test equipment does not contact the vehicle chassis.

## 2. RADIO ALIGNMENT AND ADJUSTMENTS

### 2.1 INTRODUCTION

2.1.1 The following six adjustments can be performed on the *SYNTOR X* high-band radio:

- oscillator frequency
- deviation
- compensation
- transmitter high-power output
- transmitter low-power output
- transmitter power amplifier current limit.

2.1.2 The oscillator frequency, deviation, modulation compensation, and transmitter high power adjustments can be performed through holes that are directly accessible on the rf board, as shown in Figure 1.

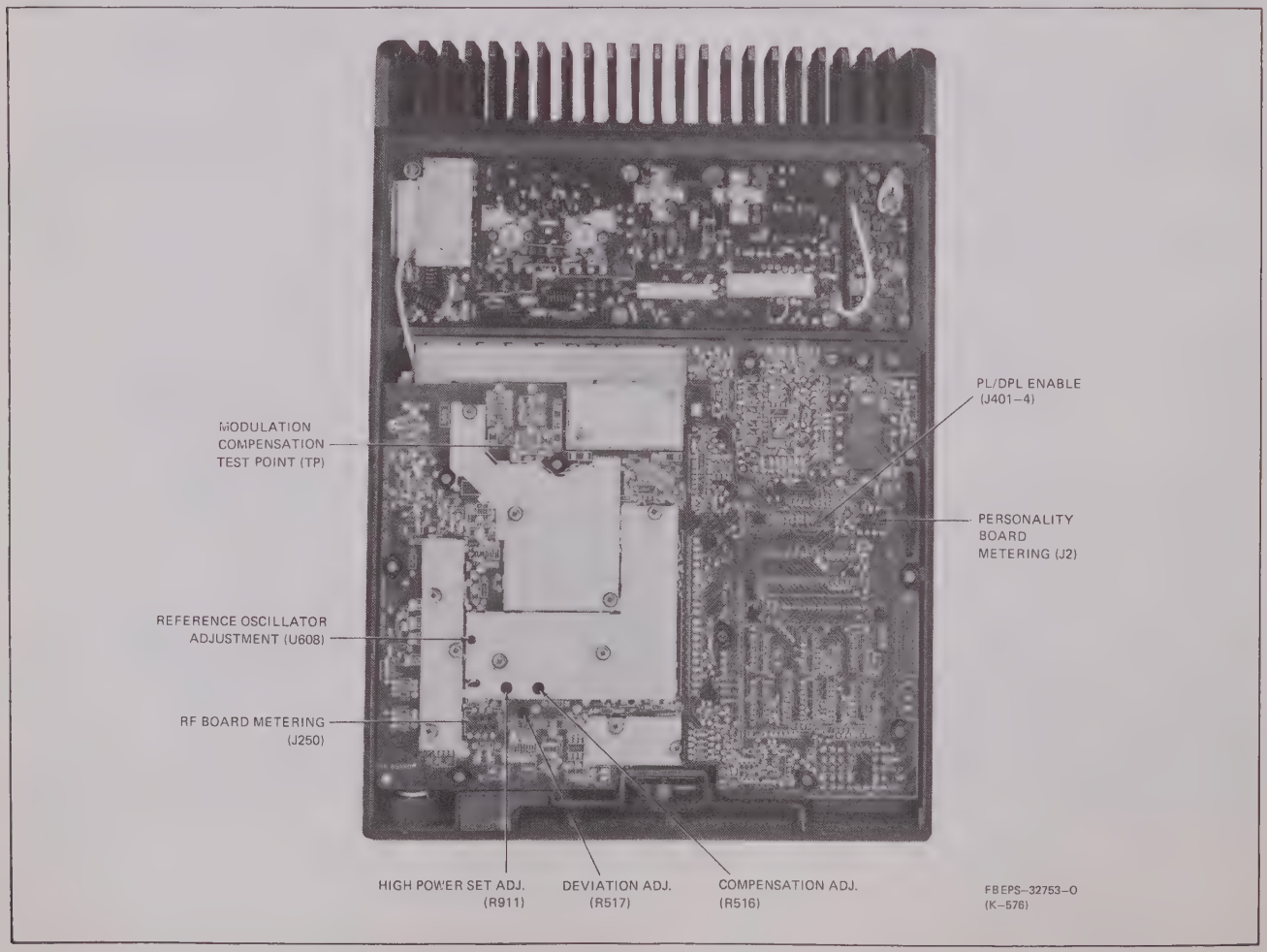



*Figure 1. Radio Adjustments Locations (Top View)*

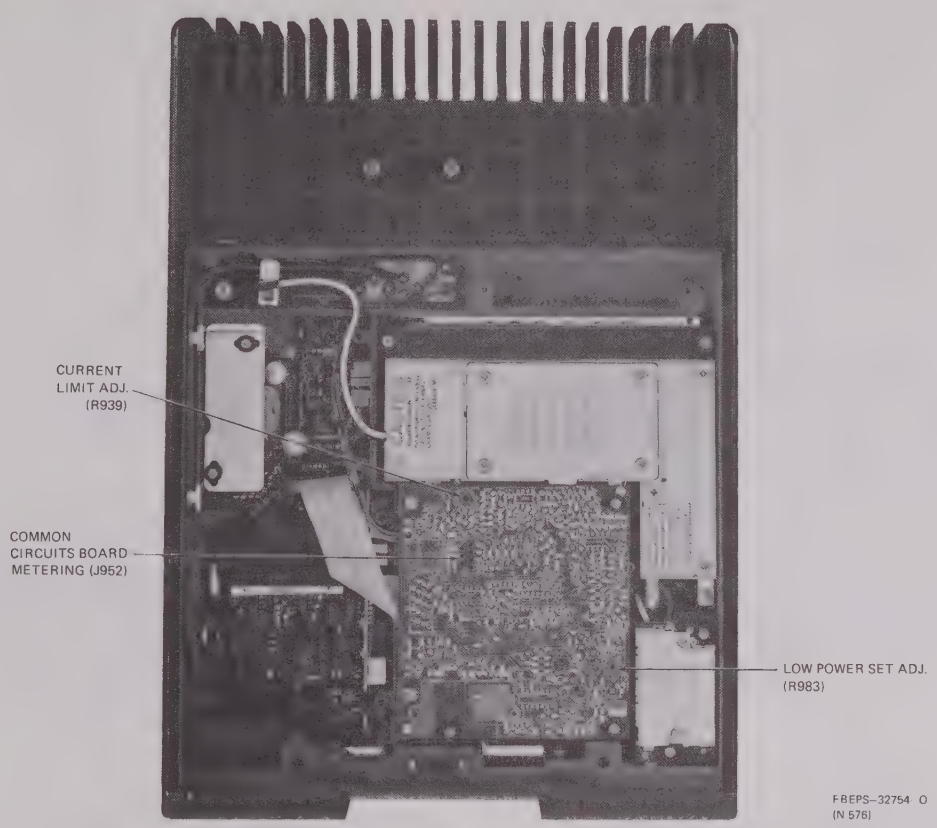



*Figure 2. Radio Adjustments Locations (Bottom View)*

2.1.3 The transmitter low power and transmitter power amplifier current limit adjustments can be performed after removing the bottom cover and exposing the holes that are located on the common circuits board (refer to Figure 2).

**IMPORTANT**

Readjustment of the *SYNTOR X* receiver is NOT recommended, since the receiver is preadjusted at the factory to provide a wide passband for all frequencies within the 150 MHz to 174 MHz range.

**NOTE**

Refer to the list of recommended test equipment provided in this section of the manual.

## 2.2 OSCILLATOR FREQUENCY

**NOTE**

The oscillator frequency adjustment should be performed before setting or checking the deviation adjustment.

Step 1. Set the mode selector switch to mode 1.

Step 2. Using the portable test set, key the transmitter without modulation. On tone and *Digital Private- Line* radios, disable the encoder output by shorting the PL/DPL ENABLE line (J401-4) to ground. J401-4 is located on the personality board.

Step 3. Adjust the reference oscillator (U608) warp control (Figure 1) until the proper indication is obtained on the frequency meter.

Step 4. Set the mode selector switch (for multi-mode units only) to all the remaining positions and check the proper transmitter frequencies. (No further oscillator frequency adjustments are required.)

## 2.3 DEVIATION

**NOTE**

While setting deviation, it is important to check deviation on all transmit channels. This ensures that the radio will not over-deviate.

Step 1A. (For PL or DPL radios only) Using the DEVIATION ADJ. potentiometer (Figure 1), set deviation on the lowest PL or DPL encoded customer radio frequency to ±4.70 kHz.

Step 1B. (For radios without PL or DPL) Set voice modulation to ±4.70 kHz on the lowest customer frequency.

## 2.4 COMPENSATION

**NOTE**

The compensation adjustment potentiometer (R516) is set at the factory and, normally, does not require readjustment. However, the compensation adjustment procedure should be used whenever any of the following conditions occur in a radio: (a) if DPL transmit (encode) performance is poor, (b) if the VCO reference oscillator or common circuits board is replaced, (c) if the compensation potentiometer is replaced or inadvertently adjusted. This procedure sets the ratio of the transmit audio signal between the VCO and reference oscillator, thus insuring good DPL waveform fidelity and flat modulation response.

Step 1. Turn the deviation potentiometer (Figure 1) halfway in a clockwise direction.

Step 2A. (For PL or DPL radios only) Set the radio to the customer frequency closest to 162 MHz.

Step 2B. (For radios without PL or DPL) Apply a 100 Hz (±1 kHz deviation) signal to the microphone input.

Step 3. Connect the center lead of the shielded cable of an ac voltmeter to the modulation compensation test point (Figure 1) and connect the shield to the radio ground (A-). Set the voltmeter to the 1 mV range.

Step 4A. (For PL or DPL radios only) Modulate the PL or DPL and adjust the compensation potentiometer until a null indication is obtained on the voltmeter. Cover the hole with tape to prevent accidental adjustment of this control.

Step 4B. (For radios without PL or DPL) With a 100 Hz signal applied to the microphone input, adjust the compensation potentiometer until a null indication is obtained on the voltmeter. Cover the hole with a tape to prevent accidental adjustment of this control.

Step 5A. (For PL or DPL radios only) Using the deviation potentiometer (Figure 1), set deviation on the lowest PL or DPL customer frequency to ±4.7 kHz.

Step 5B. (For radios without PL or DPL) Set voice modulation to ±4.7 kHz on the lowest customer frequency.

## 2.5 TRANSMITTER POWER

**NOTE**

Use of coaxial cable adapters allowing interconnectors of differing cables is not recommended. Use of differing sized cables may increase the output VSWR and cause protection circuitry to reduce output power. Use only cables which connect directly to the test equipment used. Refer to the Transmitter section of this manual for information concerning operation of the VSWR protection circuitry.

**NOTE**

Refer to the list of recommended test equipment provided in this section of the manual. It is recommended that only the recommended equipment be used in these adjustments to avoid erroneous results.

**NOTE**

All the transmitter adjustments described in the following procedure can be performed from the bottom of the radio, through the holes located on the common circuits board (refer to Figures 1 and 2). Use a TEK-5 Meter Panel with a TEK-40 Cable or the S1056 Portable Test Set.

Step 1. Terminate the radio with a wattmeter and a 50-ohm load.

Step 2. Adjust the dc power supply voltage to 13.4 volts.

Step 3. Rotate the following potentiometers fully counterclockwise: R911, R939, and R983 (refer to Figures 1 and 2).

Step 4. Select a channel programmed for high power output; key the transmitter and adjust R911 until a nominal power output of 115 W is obtained.

Step 5. Observe Meter 5 (final PA current) and determine the least sufficient high power output channel (highest Meter 5 indication).

Step 6. Rotate R911 fully clockwise and select the least efficient high power output channel (as determined in Step 5).

Step 7. Key the transmitter and rotate R939 until Meter 5 provides an indication that is 3 uA higher than the one observed in Step 5. If the 3 uA increase cannot be obtained, slowly rotate R939 and note the maximum Meter 5 indication. Now adjust R939 for an indication that is less than 0.5 uA below the noted maximum. For example, if Meter 5 provides a 15 uA indication in Step 5, and if a maximum indication of 16.5 uA is obtained by rotating R939, then R939 should be adjusted for an indication of approximately 16.4 uA (i.e., a difference of 16.5-16.4 = 0.1 uA).

Step 8. Key the transmitter and adjust R911 for an output power indication of 115 W. Check the power output on all the high power output channels and readjust R911, as required, until an indication of 115 W is obtained on all channels.

Step 9. Select a channel programmed for low power output; key the transmitter and adjust R983 until a 55 W indication is obtained (if W261 is ordered) or 10 W (if W266 is ordered).

Step 10. Check the power output on all the lower power output channels and readjust R983, as required, for a minimum power output indication of 55 watts (W261) or 10 watts (W277) on all these channels.

**NOTE**

A properly aligned transmitter should provide the indications presented in Table 1.

*Table 1. Meter Indications for Properly Aligned Transmitter*

| Transmit Mode | Meter 5 Indication (in uA) |
|---|---|
| High power output (110 watts) | 12, min.<br>23, max. |
| Low power output (10 watts) | 6, min.<br>12, max. |
| Medium power output (55 watts) | 8, min.<br>20, max. |

## 3. RADIO DISASSEMBLY

### 3.1 GENERAL

3.1.1 The solder side of the rf board, personality board, and the power amplifier deck can be accessed from the top of the radio after removing the top cover. The top cover is removed by turning the key to release the front handle and then pushing the button under the handle. Once this is done, the top cover pops up, providing access to the boards. Access to the PA deck requires the lifting up of the PA shield. This procedure provides access to the metering sockets of the rf board (J250) and of the personality board (J2), without removing the radio from its mounting tray.

3.1.2 The radio can be removed from the vehicle by, first, releasing the handle, as described above. The radio can then be slid forward (about an inch) and lifted out. Disconnection of the cables allows removal of the radio from the trunk.

3.1.3 The rest of the radio can be accessed by removing the four screws that secure the skid plate to the bottom of the radio. Removal of the skid plate provides access to the metering socket of the common circuits board (J952). The common circuits board is hinged so that when turned on its hinge it provides access to its component side as well as to the component side of the rf board. (Refer to Figures 1 and 2 in the Description section of this manual.) To turn the common circuits board on its hinge requires the removal of two screws on the board as well as one additional screw on the regulator heat sink.

**WARNING**

When operating the radio with the regulator heat sink screw removed, care should be taken to avoid the exposed hot flange.

**NOTE**

All serviceable mounting screws are posidrive heads which can be serviced with standard phillips screwdrivers. For improved driver engagement, posidrive tools are available through National Parts (Motorola Part Nos. 66-80344A57 and 66-80344A58).

**NOTE**

Mounting screws for the common circuits board, personality board, and rf board can be easily identified by the black plastic captivators that retain them to the boards.

### 3.2 COMMON CIRCUITS BOARD

To turn the common circuits board on its hinges requires the removal of three screws, but removal of the board from the radio also requires the removal of the two hinge screws. Moreover, the following should also be unplugged: (a) the ribbon cable between the common circuits board and the personality board, and (b) the wires between the common circuits board and the PA deck. While putting the common circuits board back into the radio, care should be taken to pass both the cable and the wires between the two board hinges.

### 3.3 PERSONALITY BOARD

The personality board can be removed from the radio by: (a) removing the seven screws that secure the board to the radio, (b) disconnecting the cable from the front plug, (c) disconnecting the ribbon cable from the common circuits board, (d) removing any connectors to the interface board (if used), and (e) pulling the board away from the radio to disconnect the connectors to the rf board. Placing the board back into the radio requires that care be taken to insure that the front plug gasket is properly seated. (Silicone compound, Motorola Part No. 1100834678, can be helpful in this process.)

### 3.4 RF BOARD

Removal of the rf board requires the following steps: (a) removal of the personality board, as explained

above, (b) removal of the six retention screws, (c) disconnection of a coaxial cable between the rf board and the internal casting, and d) disconnection of the wires located near the antenna switch. Access to some segments of the solder side of the rf board requires the removal of shields secured to the board by means of screws. On the component side of the rf board, two large cans can be removed by simply pulling them off the board; however, there are other cans which must be unsoldered to be removed.

**IMPORTANT**

Placing the rf board back into the radio requires careful alignment between the board guide posts and the internal casting. Care must be taken to match the board spring connectors with those of the internal casting.

## 3.5 INTERNAL CASTING

### 3.5.1 General

Removal of the internal casting from the radio requires the following steps.

Step 1. Remove four cover mounting screws from the bottom of the radio.

Step 2. Remove three screws to allow the common circuits board to hinge.

Step 3. Remove four casting mounting screws.

Step 4. Remove two screws from the rf board (from the top side of the radio).

Step 5. Disconnect the coaxial cable between the internal casting and the PA deck.

Step 6. Disconnect a set of rf board wires located near the antenna switch.

Step 7. Disconnect the coaxial cable from the rf board.

Step 8. Disconnect the coaxial cable from the antenna relay.

During the reassembly operation, care should be exercised to make the proper connections between the various connectors and to replace all the screws without omission.

### 3.5.2 First Mixer

To remove the first mixer: (a) remove the two screws that secure the first mixer cover and gasket to the internal casting, (b) carefully unsolder the two tap leads from the first mixer to the filters, (c) remove solder between the feedthrough and the circuit board, and (d) remove the two screws that hold the circuit board to the internal casting. Now the first mixer board can be removed.

**CAUTION**

Do not use excessive heat. Otherwise the tap leads will come off the filter.

### 3.5.3 Low-Pass Filter Board (or Optional Preamplifier)

Once the cover and gasket over the low-pass filter board (or preamplifier) has been removed, the low-pass filter board (or preamplifier) can be removed as explained in the following steps.

Step 1. Carefully, and without using too much heat, unsolder and remove the wires between the printed circuit board and the phono connector.

Step 2. Carefully, and without using too much heat, unsolder and remove the coaxial cable connected to the five-pole filter.

Step 3. If a preamplifier is used, carefully unsolder the feed-through lead connected to the preamplifier board.

Step 4. Unscrew and remove the two retaining screws of the board.

Now the low-pass filter board (or preamplifier) can be removed with ease.

### 3.5.4 VCO Assembly

The VCO assembly is removed as follows:

Step 1. Remove the four screws that secure the VCO assembly cover.

Step 2. Disconnect the two coaxial cables from the substrate.

Step 3. Remove the screw from the center of the VCO carrier PC board.

Now the VCO assembly can be removed by lifting and disconnecting it from the 7-pin connector.

**NOTE**

If the VCO assembly is replaced, it will be necessary to readjust the compensation level, as explained in the Radio Adjustment Procedures presented in the General Maintenance section of this manual.

3.5.5 VCO Buffer

The VCO buffercan be removed by disconnecting the two coaxial cables from the VCO, unplugging the coaxial cable from the rf board, and unplugging the coaxial cable from the PA deck. After removing the two mounting screws, the VCO buffer assembly can be removed by lifting the handle (the handle forms part of the carrier). Lifting the carrier will simultaneously disengage the connector to the three-pole injection filter. This filter is located directly under the carrier.

3.6 TRANSMITTER PA DECK

3.6.1 To remove the power amplifier board, remove the four transistor mounting screws, the two stud nuts (which are accessible from the chassis bottom), and the PC board mounting screws and nuts. Unsolder and remove the input and output coaxial cables and all the power amplifier feedthrough capacitors from the board.

**NOTE**

Make sure that the solder is completely molten around the leads before attempting vacuum suction.

3.6.2 To remove the IPA board, remove the two circuit board mounting screws as well as the transistor heat sink mounting screw and shoulder washer. Also unsolder the PA board output cable and then remove the IPA board.

**CAUTION**

During reassembly of the board, care should be taken to insure that the insulator and shoulder washer are providing proper insulation between the transistor heat sink and the radio chassis.

3.7 FRONT LATCH

The front latch key mechanism can be removed by inserting the key into the lock, turning the key about 45 degrees in a clockwise direction, and inserting the special removal tool (Motorola Part No. 66-84909B01). This tool is inserted with the point directed away from the lock and twisting it 180 degrees in a clockwise direction. This releases the key mechanism, which can then be removed. Removal of the black plastic part requires the removal of a single screw.

3.8 DIRECTIONAL COUPLER BOARD

The directional coupler board can be removed by, first, removing the two PC board mounting screws and gently pulling the board out of the radio until the two phono connectors and the dc connector are exposed. Unplug the two phono connectors and lift up the board from the radio.

3.9 ANTENNA RELAY

First, remove the directional coupler board, as explained above. The antenna relay can now be removed by disconnecting the dc connector from the rf board and unplugging the coaxial cable from the internal casting. The antenna relay is secured by means of a nut located outside the radio chassis. Removal of this nut requires the use of a spanner nut removal tool (Motorola Part No. RSX4028A).

## 4. GENERAL SYSTEM TROUBLESHOOTING GUIDE

4.1 A general system troubleshooting guide is provided in Table 2. This table is divided into three sections: symptoms of malfunction, possible cause of failure, and the procedure to be adopted to clear the fault. The failure symptoms deal with the following conditons: absence of receive audio, distorted receive audio, low audio power, radio does not squelch, radio does not unsquelch, improper squelch sensitivity, no PL/DPL decode, no regulated 9.6 V or 5.0 V, no rf power output, low rf power output, no transmitter modulation, distorted transmitter modulation, improper microphone sensitivity, transmitter frequency shift with high-level modulation, synthesizer does not lock, reference frequency (5 or 6.25 kHz) heard in speaker or on transmitted audio, synthesizer locks on wrong frquency, slow synthesizer lock time, poor receive sensitivity, alternator whine.

4.2 Depending on the cause of failure, the following troubleshooting charts and schematic diagrams are referred to for consultation:

- Schematic diagram of the audio section of the personality board; this diagram provides various voltage levels and waveforms and is located in the Microcomputer System section of this manual.
- Squelch troubleshooting chart; this is located in the Receiver section of this manual.
- Regulator troubleshooting guide; this is located in the Common Circuits Board section of this manual.
- Synthesizer troubleshooting chart; this is located in the Synthesizer section of this manual.
- Microcomputer troubleshooting chart; this is located in the Microcomputer System section of this manual.
- Transmitter control and protection circuitry troubleshooting chart; this is located in the Transmitter section of this manual.
- Power amplifier troubleshooting chart; this is located in the Transmitter section.
- IDC troubleshooting chart; this is located in the Synthesizer section.

- Radio alignment and adjustment procedures; this is located in the General Maintenance section.
- Receiver troubleshooting chart; this is located in the Receiver section.

*Table 2. General System Troubleshooting Guide*

| Symptom | Possible Source of Trouble | Chart or Diagram To Be Referred To |
|---|---|---|
| No Receive Audio | Red or green lead fuse | Check the fuses |
| | Audio PA malfunction | Voltages and waveforms on audio schematic diagram |
| | Audio enable switch | Squelch troubleshooting chart |
| | Squelch malfunction | Squelch troubleshooting chart |
| | Regulator malfunction | Regulator troubleshooting guide |
| | Synthesizer not locking | Synthesizer troubleshooting chart |
| | Microcomputer malfunction | Microcomputer troubleshooting chart |
| | Quad detector malfunction | Receiver section schematic diagram |
| Distorted Receiver Audio | Audio PA malfunction | Audio schematic diagram for voltages and waveforms |
| | Quad detector malfunction | Receiver section schematic diagram |
| | I-F malfunction | Receiver section schematic diagram |
| Low Audio Power | Audio PA malfunction | Audio schematic diagram |
| | Red lead fuse | Check fuse |
| | Quad detector malfunction | Receiver section schematic diagram |
| | I-F malfunction | Receiver section schematic diagram |
| Radio Does Not Squelch | Squelch malfunction | Squelch troubleshooting chart |
| | Microcomputer malfunction | Microcomputer troubleshooting Chart |
| | Audio enable switch | Squelch troubleshooting chart |
| Radio Does Not Unsquelch | Refer to *No Receive Audio* Symptom Above | |
| Improper Squelch Sensitivity | I-F malfunction | Receiver section schematic diagram |
| | Quad detector malfunction (low recovery) | Receiver section schematic diagram |
| | Squelch malfunction | Squelch troubleshooting chart |
| No PL/DPL Encode | I/O board malfunction | Troubleshoot I/O board; refer to I/O board schematic diagram. |
| | Microcompuer malfunction | Microcompuer troubleshooting chart |
| | IDC malfunction | IDC portion of synthesizer troubleshooting chart |
| No PL/DPL Decode | I/O board malfunction | Troubleshoot I/O board; refer to I/O board schematic diagram |
| | Microcomputer malfunction | Microcompuer troubleshooting chart |
| No Regulated 9.6 V or 5.0 V | Short on printed circuit board | — |
| | Regulator malfunction | Regulator troubleshooting guide |
| No RF Power Output | PA enable switch | Microcomputer schematic diagram |
| | Keyed 9.4 switch | Microcomputer schematic diagram |
| | Synthesizer out-of-lock | Synthesizer troubleshooting chart |
| | Red or orange lead fuse | Check fuses |
| | Power control malfunction | Troubleshoot PTT isolation circuit; refer to microcomputer schematic diagram |
| | PA malfunction | PA troubleshooting chart |
| No Power Control | Power control malfunction | Power control troubleshooting chart |
| Low RF Power Output | Power control malfunction | Power control troubleshooting chart |
| | PA malfunction | PA troubleshooting chart |
| | Antenna rely malfunction | Antenna relay test procedure |
| No Transmitter Modulation | IDC malfunction | IDC portion of synthesizer troubleshooting chart |
| | Power control malfunction | IDC portion of synthesizer troubleshooting chart |
| Distorted Transmitter Modulation | Misadjusted compensation | Compensation adjustment procedure (in radio alignment and adjustment) |
| | IDC malfunction (PL/DPL distortion only) | IDC portion of synthesizer troubleshooting chart |
| | I/O board malfunction | Troubleshoot I/O board (refer to the I/O board schematic diagram) |
| | Reference oscillator malfunction | IDC portion of synthesizer troubleshooting chart. |
| | VCO malfunction | IDC portion of synthesizer troubleshooting chart. |

*Table 2. General System Troubleshooting Guide (Cont'd.)*

| Symptom | Possible Source of Trouble | Chart or Diagram To Be Referred To |
|---|---|---|
| Improper Microphone Sensitivity | IDC malfunction | |
| | VCO malfunction | |
| | Reference oscillator malunction | |
| Transmitter Frequency Shift with High-Level Modulation | IDC malfunction | IDC portion of synthesizer troubleshooting chart. |
| Synthesizer Does Not Lock | Is radio scanning? | Out-of-lock LED will light if radio is scanning. |
| | Synthesizer malfunction | Synthesizer troubleshooting chart. |
| | Microcomputer malfunction | Microcomputer troubleshooting chart. |
| | Memory module malfunction | Programming section of synthesizer troubleshooting chart. |
| Reference Frequency (6.25 kHz) Heard in Speaker or on Transmitted Audio | Adaptive filter malfunction | Synthesizer troubleshooting procedure. |
| Synthesizer Locks on Wrong Frequency | Synthesizer malfunction | |
| | Microcomputer malfunction | |
| | Memory module malfunction | Synthesizer troubleshooting chart. |
| | Reference oscillator out of adjustment | |
| Long Synthesizer Lock Time | Synthesizer malfunction | Synthesizer troubleshooting chart. |
| | VCO malfunction | |
| Poor Receive Sensitivity | High I-F malfunction | |
| | Low I-F malfunction | Receiver troubleshooting chart. Also refer to receiver section schematic diagram. |
| | Quad detector malfunction | |
| | Preamplifier malfunction | |
| | First mixer malfunction | |
| | Second mixer malfunction | |
| | Antenna relay malfunction | Antenna relay test procedure. |
| Alternator Whine | Chassis to A-short | Disconnect control cable and check for a short between chassis and A-. |
| | Excessive whine in vehicle | Refer to manual 68P81116A74. |

## 5. ANTENNA SWITCH TEST PROCEDURE

### 5.1 INTRODUCTION

When the radio is in the receive mode, the antenna switch connects the antenna to the receiver via the receiver reed, coaxial cable, and phono plug; when in the transmit mode, the antenna switch connects the antenna to the transmitter via the transmitter reed, coaxial cable, directional coupler, and harmonic filter (see Figure 3).

### 5.2 TEST EQUIPMENT

A regular analog VOM is required for checking continuity paths or short circuits. Refer to the list of recommended test equipment provided in the table located in this section.

### 5.3 PROCEDURE

#### 5.3.1 Types of Tests

This procedure consists of the following two tests:

(a) receive signal path test and (b) transmit signal path test. As an initial step, *disconnect the coaxial cable to the IPA deck input.* This allows the antenna switch to change from one condition to the other (i.e., from receive to transmit or vice versa) without causing the generation of PA output power.

#### 5.3.2 Receive Signal Path Test

Step 1. Disconnect the receive cable plug from the internal casting socket. Using an ohmmeter, verify that continuity exists between the plug center pin and the antenna connector center pin. Verify that no continuity exists between the plug center pin and the plug shield (and/or radio chassis).

Step 2. Key up the radio and verify that a 9.4 dc voltage is present at the antenna switch coil. Under this condition, the receive reed opens. Verify that no continuity exists between the antenna switch center pin and the receive cable plug center pin.

#### 5.3.3 Transmit Signal Path Test

Step 1. Verify that the coaxial cable is still disconnected from the PA deck input.

Step 2. Remove the phono connector from the directional coupler board.

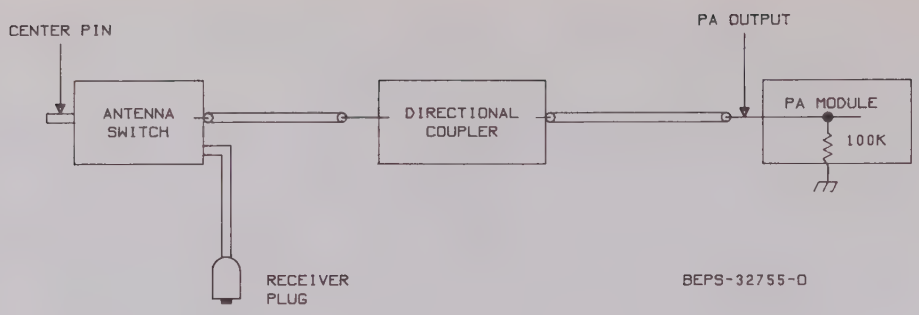



*Figure 3. Transmit Signal Path*

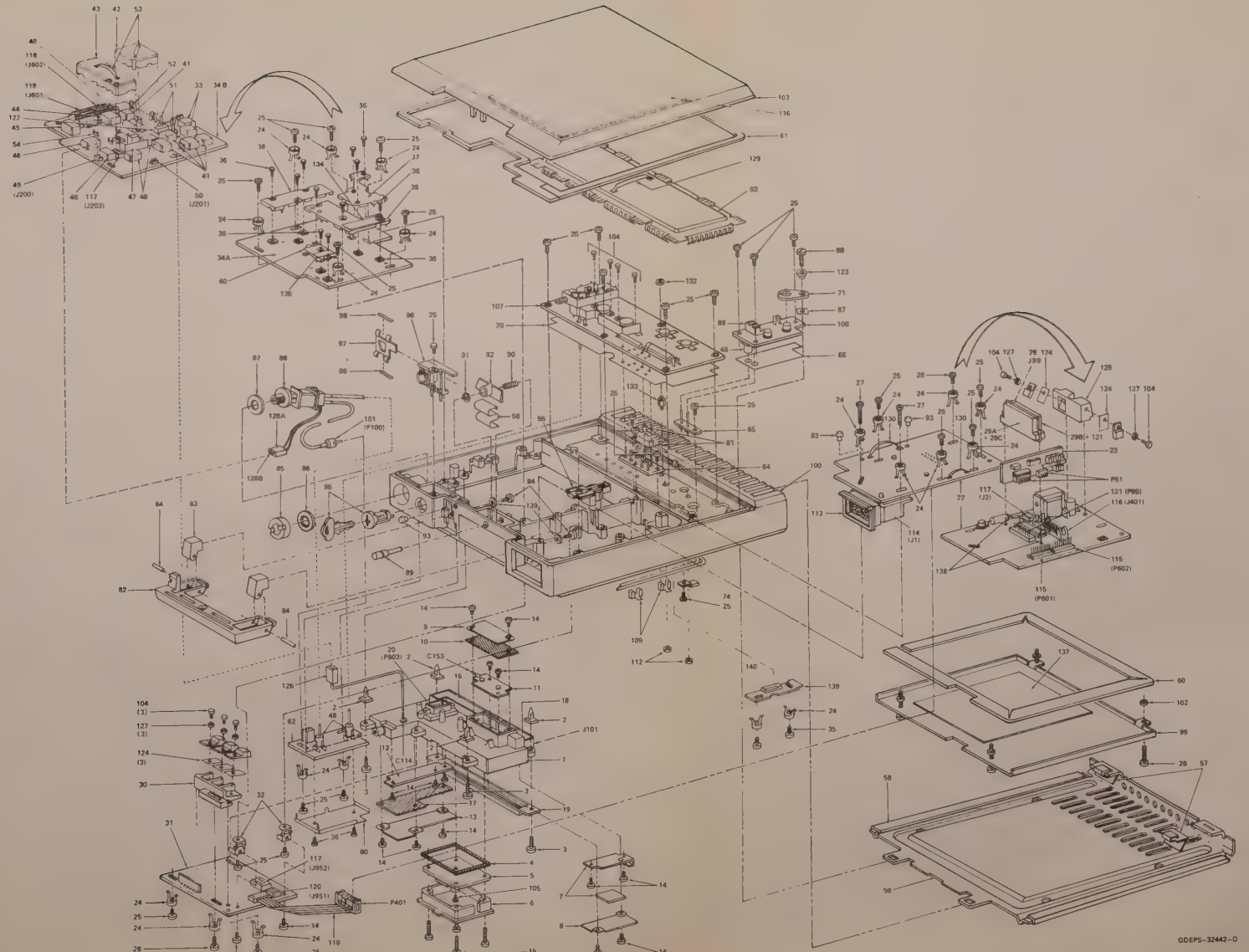
Step 3. Key up the transmitter and verify that continuity exists between the phono connector center pin and the antenna switch center pin. If continuity exists, check other points along the transmit path to locate any possible open circuits (Figure 3). If no continuity exists, replace the antenna switch.

Step 4. Verify that the transmitter path to the radio chassis is not less than 50 kilohms.

**IMPORTANT**

Field servicing of the antenna switch assembly is NOT recommended. Consequently, a defective unit must be replaced in its entirety.

# EXPLODED VIEW OF RADIO AND MECHANICAL PARTS LIST



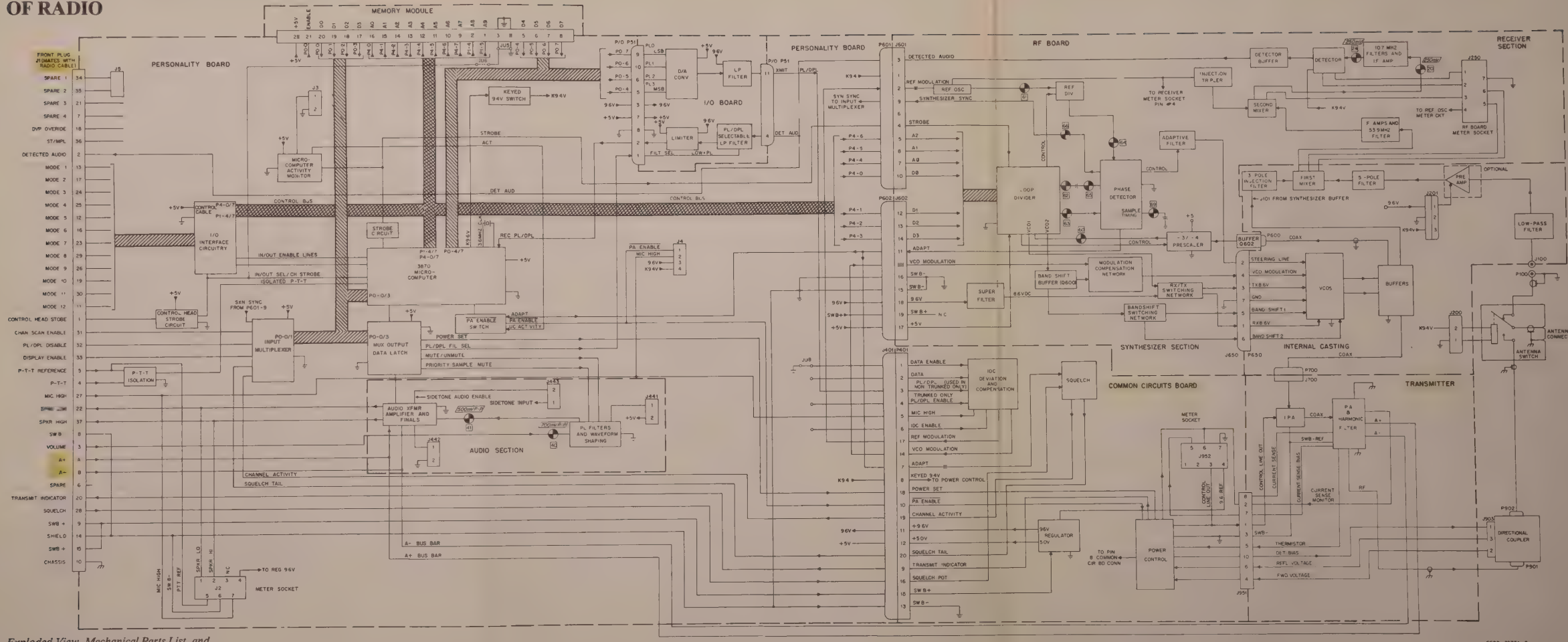

## parts list

Radio Mechanical Parts PL-7598-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| 1 | 15-84776M01 | HOUSING, internal casting |
| 2 | 14-80212B01 | NUT, expansion; 4 used |
| 3 | 3-82002N01 | SCREW, tapping; 4.2 x 1.41 x 19 mm; 4 used |
| 4 | 32-82796H01 | GASKET, wire mesh |
| 5 | 8LD4103A | VCO, substrate |
| 6 | 15-84817M01 | COVER, VCO |
| 7 | HLN4249A | VCO, buffer, substrate |
| 8 | 15-84851M01 | COVER, buffer |
| 9 | 15-84852M01 | COVER, mixer |
| 10 | 32-80042D01 | GASKET, mixer |
| 11 | HLD4108A | CIRCUIT BOARD, mixer |
| 12 | HLN4250A | CIRCUIT BOARD, preamplifier |
| 13 | 15-84853M01 | COVER, low pass filter |
| 14 | 3-10943C28 | SCREW, tapping; 3.5 x 0.6 x 6 mm; 18 used |
| 15 | 3-82001N01 | SCREW, tapping; 3.5 x 0.6 x 25 mm; 4 used |
| 16 | 15-80209B01 | COVER, preselector (5-cell) |
| 17 | 32-80043D01 | COVER, preselector (2-cell) |
| 18 | 15-80210B02 | COVER, preselector (3-cell) |
| 19 | 15-83894M01 | COVER, preselector tuning |
| 20 | HLN4251A | VCO INTERCONNECT |
| 21 | — | NOT USED |
| 22 | HLN4237A | CIRCUIT BOARD, personality |
| 23 | TRN8878A | CIRCUIT BOARD, input/output |
| 24 | 42-83503M01 | RETAINER; 16 used |
| 25 | 3-10943C29 | SCREW, tapping; 3.5 x 0.6 x 8 mm; 13 used |
| 26 | 3-10943C32 | SCREW, tapping; 3.5 x 0.6 x 16 mm |
| 27 | 3-82001N02 | SCREW, tapping; 3.5 x 0.6 x 25 mm |
| 28 | TRN8864A | PROM BOARD, 8 and 16-mode |
| | or | |
| | TRN8865A | PROM BOARD, 32-mode |
| 29A | 15-83494M01 | HOUSING, PROM: left-half |
| 29B | 15-83819M01 | HOUSING, PROM: right-half |
| 29C | 54-84392M01 | LABEL, direction |
| 30 | 26-84835M01 | HEATSINK, regulator |
| 31 | HLN4240A | CIRCUIT BOARD, common circuits |
| 32 | 55-83493M01 | HINGE; 2 used |
| 33 | 26-84898M01 | SHIELD, circuit board; 2 used |
| 34A | HLN4239A | CIRCUIT BOARD, rf (solder side) |
| 34B | HLN4239A | CIRCUIT BOARD, rf (component side) |
| 35 | 3-84220B01 | GROMMET; 11 used |
| 36 | 3-84256M01 | SCREW, tapping; 11 used |
| 37 | 26-84862M01 | SHIELD, adaptive filter (solder side) |
| 38 | 26-83586M01 | SHIELD, lower I-F (solder side) |
| 39 | 26-80207D01 | SHIELD, divider/phase detector (solder side) |
| 40 | 26-83587M01 | SHIELD, quadrature detector (solder side) |
| 41 | 26-83594M01 | SHIELD, can (component side); 5 used |
| 42 | 26-84978M01 | SHIELD, adaptive filter (component side) |
| 43 | 26-83593M01 | SHIELD, divider/phase detector (component side) |
| 44 | 26-83597M01 | SHIELD, prescaler (component side) |
| 45 | 26-83595M01 | SHIELD, quadrature detector |
| 46 | 26-83596M01 | SHIELD, lower I-F (component side); 4 used |
| 47 | 26-83814M01 | SHIELD, fence (component side) |
| 48 | 9-84231B02 | CONNECTOR, phono, male |
| 49 | 28-84324M01 | CONNECTOR, male; 2-contact |
| 50 | 28-84324M02 | CONNECTOR, male; 3-contact |
| 51 | 46-83949M01 | GUIDE POST; 2 used |
| 52 | 42-83891L01 | CLIP, mixer; 4 used |
| 53 | 55-84300B02 | HANDLE; 2 used |
| 54 | 42-82160N01 | CLIP, speed; 10 used |
| 55 | HLN4248A | PA BUS WIRING |
| 56 | 41-80158B01 | SPRING, cover lift |
| 57 | 41-80172B01 | SPRING, clip; 2 used |
| 58 | 7-80173B01 | RAIL, guide; 2 used |
| 59 | 7-80171B01 | FRAME, mounting |
| 60 | 32-80175B01 | GASKET, bottom cover |
| 61 | 32-80176B01 | GASKET, top cover |
| 62 | HLN4242A | CIRCUIT BOARD, directional coupler |
| 63 | 26-84786M01 | SHIELD, PA cover |
| 64 | HLN4046A | PLATE, feed thru (power amplifier) |
| 65 | HLN4244A | PLATE, feed thru (I.P.A.) |
| 66 | 14-84985M01 | INSULATOR, I.P.A. |
| 67 | 14-80103B01 | INSULATOR, heatsink (I.P.A.) |
| 68 | 3-10936A14 | SCREW, tapping; 3.5 x 0.8 x 12 mm |
| 69 | 9-83445L10 | SOCKET, 3-position |
| 70 | 14-80143A04 | INSULATOR, PA |
| 71 | 26-80016B01 | HEATSINK, I.P.A. |
| 72 | — | NOT USED |
| 73 | — | NOT USED |
| 74 | 42-80201B01 | CLIP, bus wire |
| 75 thru 79 | — | NOT USED |
| 80 | 26-80263C01 | SHIELD, directional coupler |
| 81 | 29-83897M01 | TERMINAL, wire receptacle; 2 used |
| 82 | 55-80107B01 | HANDLE |
| 83 | 7-80152B01 | BRACKET, handle pivot; 2 used |
| 84 | 22-83491M01 | PIN, spring |
| 85 | 2-80006A01 | NUT, spanner |
| 86 | 4-114522 | WASHER, lock |
| 87 | 32-80080A01 | GASKET, ring |
| 88 | HLN4241A | SWITCH, antenna |
| 89 | 38-80154B01 | BUTTON, cover release |
| 90 | 41-80155B01 | SPRING, cover release |
| 91 | 42-80156B01 | RETAINER, ring |
| 92 | 55-80157B01 | CATCH, cover release |
| 93 | 75-838826 | BUMPER, rubber |
| 94 | 3-10903B75 | SCREW, machine; 5.0 x 0.8 x 16 mm; 2 used |
| 95 | 55-84101B01 | LOCK W/KEY |
| 96 | 15-80159B01 | HOUSING, lock |
| 97 | 55-80161B01 | CATCH, lock |
| 98 | 41-80160B01 | SPRING, lock |
| 99 | 15-80174B01 | COVER, bottom |
| 100 | 15-84763M01 | HOUSING, radio |
| 101 | 28-82365D02 | CONNECTOR, phono; male |
| 102 | 4-80149A01 | WASHER, captive; 4 used |
| 103 | 15-80106B01 | COVER, top |
| 104 | 3-10905A05 | SCREW, machine; 3.0 x 0.5 x 8 mm, 9 used |
| 105 | 3-10943C20 | SCREW, tapping; 3.0 x 0.5 x 8 mm; 6 used |
| 106 | — | NOT USED |
| 107 | HLD4076A | CIRCUIT BOARD, power amplifier |
| 108 | HLN4247A | CIRCUIT BOARD, I.P.A. |
| 109 | 42-84367M01 | CLIP, wire hold-down; 2 used |
| 110, 111 | — | NOT USED |
| 112 | 2-7003 | NUT, stud mounting |
| 113 | 32-80219B01 | GASKET, front connector |
| 114 | 1-80708T31 | FRONT CONNECTOR ASSEMBLY, male: 37-contact, includes ref. item 113 |
| 115 | 28-82647K02 | CONNECTOR, male; 10-contact; 2 used |
| 116 | 28-83603M01 | CONNECTOR, mate; 20-contact |
| 117 | 8-84207B01 | SOCKET, metering; 7-contact; 4 used |
| 118 | 9-83445L09 | CONNECTOR, female; 10-contact |
| 119 | 30-83602M01 | CABLE, 20-conductor (incl: P401) |
| 120 | 28-80052D01 | CONNECTOR, right angle; 10-contact |
| 121 | — | NOT USED |
| 122 | 9-83729M01 | SOCKET, female; 7-contact |
| 123 | 4-84152B01 | WASHER, shoulder |
| 124 | 14-83820M02 | INSULATOR, transistor; 5 used |
| 125 | 26-83498M01 | HEATSINK, audio PA |
| 126 | 15-84301K01 | HOUSING, connector; 3-position |
| 127 | 4-84180C01 | WASHER, shoulder; 5 used |
| 128A | 15-84301K16 | CONNECTOR, housing; 2-position |
| 128B | 30-82717M01 | CONTACT, receptacle; 2 used |
| 129 | 55-84300B04 | HANDLE; long |
| 130 | 55-84300B03 | HANDLE; short |
| 131 | — | NOT USED |
| 132 | 2-10971A63 | NUT, hex-3.5 x 0.6 mm |
| 133 | 43-80013B01 | STANDOFF, circuit board |
| 134 | 14-84690M01 | INSULATOR |
| 135 | 14-84690M02 | INSULATOR |
| 136 | 14-84691M01 | INSULATOR |
| 137 | 14-84691M02 | INSULATOR |
| 138 | 48-83621M01 | ALIGNMENT PIN; memory module |
| 139 | 4-7652 | WASHER, lock; 2 used |
| | **non-referenced items** | |
| | 54-84342M01 | LABEL, floating ground (mixer cover, VCO cover); 2 used |
| | 54-84126C01 | LABEL, Motorola Rep. Parts casting wall |
| | 54-84659M01 | LABEL, patent (buffer cover) |
| | 54-850440 | LABEL, FCC |

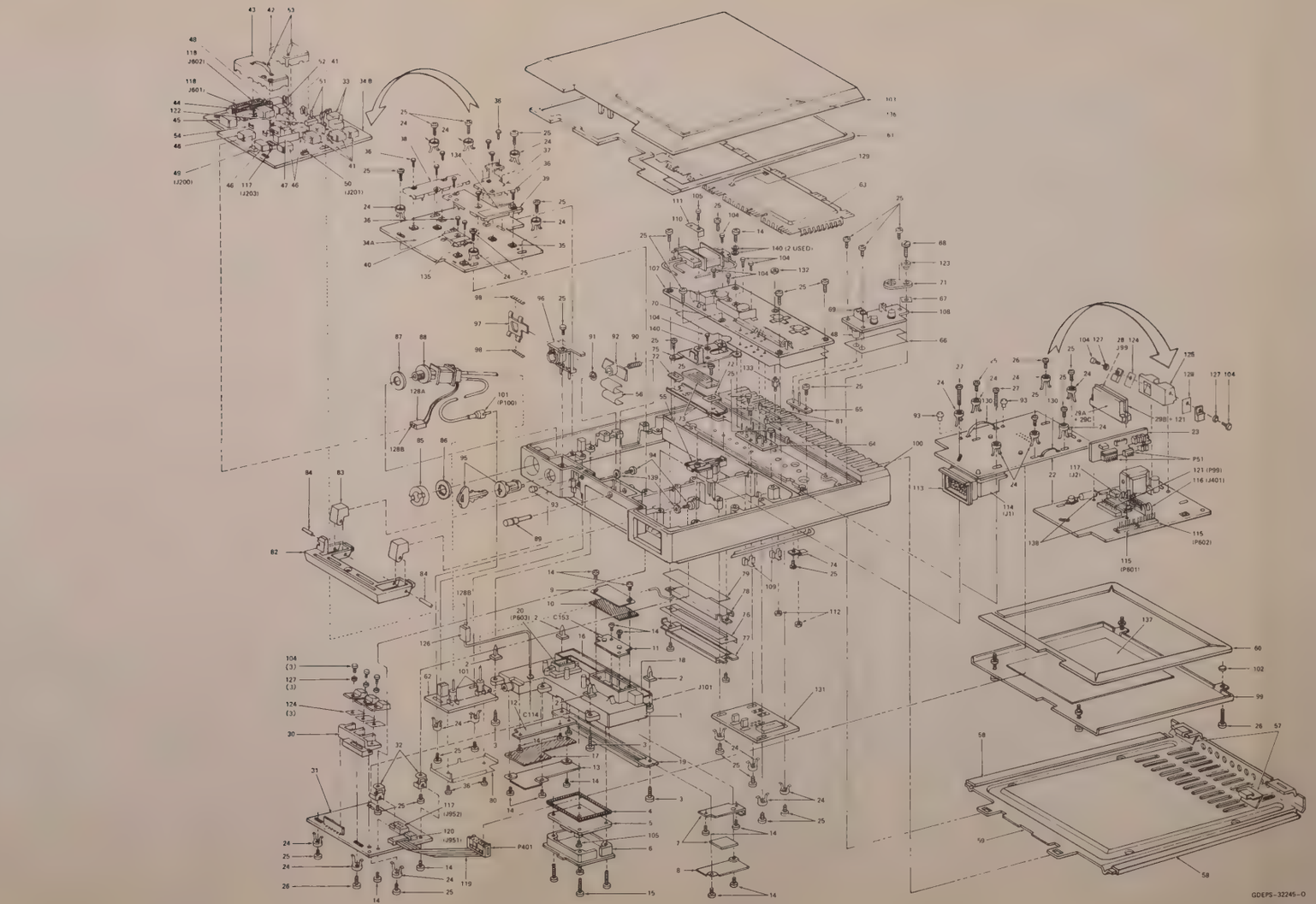
*Exploded View, Mechanical Parts List, and Functional Block Diagram of SYNTOR X High Band Systems Radio (75 W/110 W) Motorola No. PEPS-32775-O (Sheet 1 of 2)*
*10/2/81- NPC*

# FUNCTIONAL BLOCK DIAGRAM OF RADIO




*Exploded View, Mechanical Parts List, and Functional Block Diagram of SYNTOR X High Band Systems Radio (75 W/110 W) Motorola No. PEPS-32775-O (Sheet 2 of 2)*
*10/2/81- NPC*

# EXPLODED VIEW OF RADIO AND MECHANICAL PARTS LIST



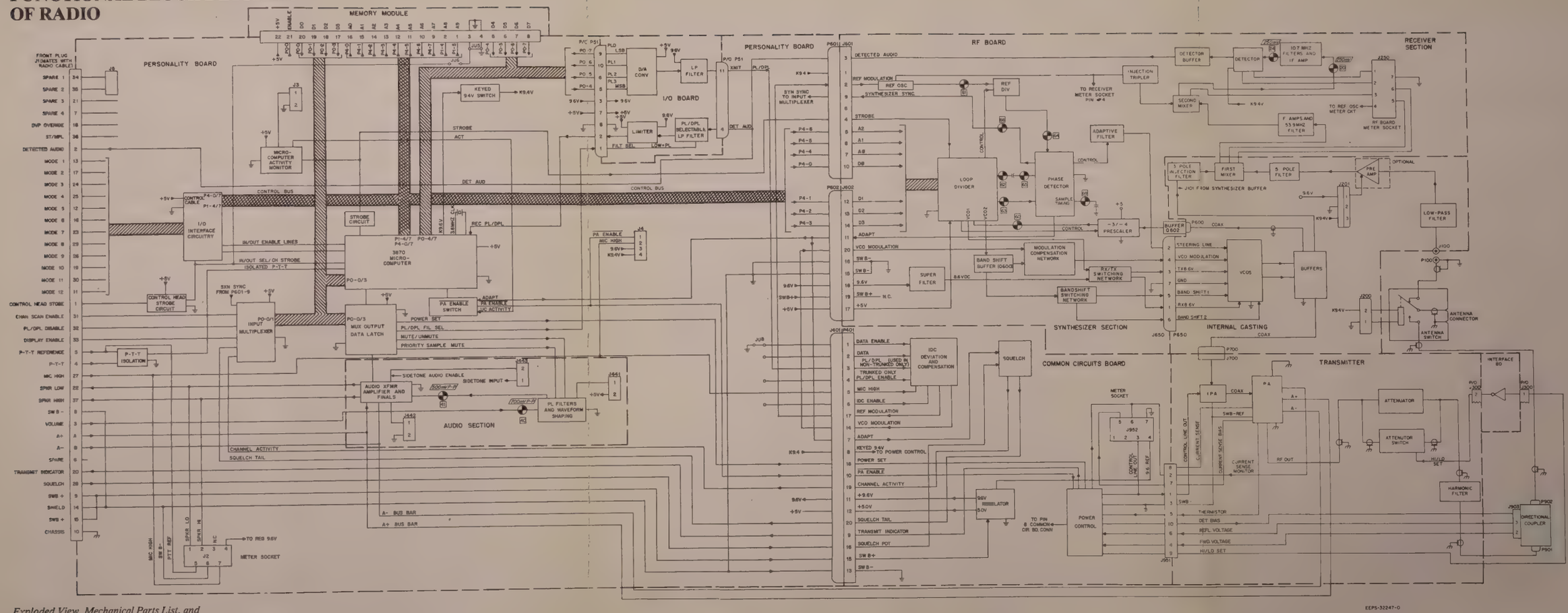

## parts list

Radio Mechanical Parts PL 7597 O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| 1 | 15-84476M01 | HOUSING, internal casting |
| 2 | 14-80212B01 | NUT, expansion; 4 used |
| 3 | 3-82002N01 | SCREW, tapping; B 4.2 x 1.41 x 19 mm; 4 used |
| 4 | 32-82796H01 | GASKET, wire mesh |
| 5 | HLD4103A | VCO, substrate |
| 6 | 15-84817M01 | COVER VCO |
| 7 | HLN1053A | VCO, buffer; substrate |
| 8 | 15-84851M01 | COVER, buffer |
| 9 | 15-84852M01 | COVER, mixer |
| 10 | 32-80042D01 | GASKET, mixer |
| 11 | HLD4108A | CIRCUIT BOARD, mixer |
| 12 | HLN4250A | CIRCUIT BOARD, low pass filter |
| 13 | 15-84853M01 | COVER, low pass filter |
| 14 | 3-10943C28 | SCREW, tapping; TT 3.5 x 0.6 x 6 mm; 18 used |
| 15 | 3-82001N01 | SCREW, tapping; TT 3.5 x 0.6 x 23 mm; 4 used |
| 16 | 15-80209B01 | COVER, preselector (6-cell) |
| 17 | 32-80043D01 | GASKET, low pass filter |
| 18 | 15-80210B02 | COVER, preselector (3-cell) |
| 19 | 15 83894M01 | COVER, preselector tuning |
| 20 | HLN4251A | VCO, interconnect |
| 21 | — | NOT USED |
| 22 | HLN4257A | CIRCUIT BOARD, personality |
| 23 | TRN5876A | CIRCUIT BOARD, input/output |
| 24 | 42 83553M01 | RETAINER, 22 used |
| 25 | 3-10943C29 | SCREW, tapping, TT 3.5 x 0.6 x 8 mm |
| 26 | 3-10943C32 | SCREW, tapping, TT 3.5 x 0.6 x 16 mm |
| 27 | 3-82001N02 | SCREW, tapping, TT 3.5 x 0.6 x 28 mm |
| 28 | TRN8864A | PROM BOARD, 8 and 16-mode |
| | or TRN8865A | PROM BOARD, 32-mode |
| | or TRN8866A | PROM BOARD, 64-mode |
| 29A | 15-83494M01 | HOUSING, PROM; left-half |
| 29B | 15-80155D01 | HOUSING, PROM, right-half |
| 29C | 54-84302M01 | LABEL, direction |
| 30 | 26-84835M01 | HEATSINK, regulator |
| 31 | HLN4240A | CIRCUIT BOARD, common circuits |
| 32 | 55-83491M01 | HINGE, 2 used |
| 33 | 26-84836M01 | SHIELD |
| 34A | HLN4239A | CIRCUIT BOARD RF (solder side) |
| 34B | | CIRCUIT BOARD RF (component side) |
| 35 | 5-84220B01 | GROMMET, 13 used |
| 36 | 3 84256M01 | SCREW, tapping; 13 used |
| 37 | 26-84862M01 | SHIELD, adaptive filter (solder side) |
| 38 | 26-83586M01 | SHIELD, lower I-F (solder side) |
| 39 | 26-80207D01 | SHIELD, divider/phase detector (solder side) |
| 40 | 26-83587M01 | SHIELD, quadrature detector (solder side) |
| 41 | 26 83594M01 | SHIELD, can (component side); 5 used |
| 42 | 26-84978M01 | SHIELD, adaptive filter (component side) |
| 43 | 26-83593M01 | SHIELD, divider/phase detector (component side) |
| 44 | 26-83597M01 | SHIELD, prescaler (component side) |
| 45 | 26-83595M01 | SHIELD, quadrature detector |
| 46 | 26-83596M01 | SHIELD, lower I-F (component side) |
| 47 | 26-83816M01 | SHIELD fence (component side) |
| 48 | 9 84231B01 | CONNECTOR phono female |
| 49 | 28-84324M01 | CONNECTOR male 2 contact |
| 50 | 28 84324M02 | CONNECTOR, male, 3 contact |
| 51 | 46-83948M01 | GUIDE POST, 2 used |
| 52 | 42 83891L01 | CLIP, mixer 4 used |
| 53 | 55-84300B02 | HANDLE 2 used |
| 54 | 42 82160N01 | CLIP, speed, 10 used |
| 55 | HLN4248A | PA bus wiring |
| 56 | 41 80158B01 | SPRING, cover left |
| 57 | 41-80172B01 | SPRING, clip, 2 used |
| 58 | 7 80173B01 | RAIL guide, 2 used |
| 59 | 7 80171B01 | FRAME, mounting |
| 60 | 32 80175B01 | GASKET bottom cover |
| 61 | 32 80176B01 | GASKET top cover |
| 62 | HLN4242A | CIRCUIT BOARD directional coupler |
| 63 | 26-84786M01 | SHIELD PA cover |
| 64 | HLN4046A | PLATE feed thru (power amplifier) |
| 65 | HLN4244A | PLATE feed thru (I P A ) |
| 66 | 14 84985M01 | INSULATOR (I P A ) |
| 67 | 14-80103B01 | INSULATOR (heatsink I P A ) |
| 68 | 3 10936A14 | SCREW, tapping, 3 5 x 0 6 x 12 mm |
| 69 | 9-83445L10 | SOCKET, 3 contact |
| 70 | 14-80209D01 | INSULATOR, PA |
| 71 | 26-80016B01 | HEATSINK (I P A ) |
| 72 | 42-80269C01 | CLIP substrate mounting |
| 73 | HLN4271A | ATTENUATOR module |
| 74 | 42-80201B01 | CLIP, bus wire |
| 75 | 7 80267C01 | BRACKET switch mounting |
| 76 | 32-83896M01 | GASKET, harmonic filter |
| 77 | 15-84827M01 | COVER harmonic filter |
| 78 | HFD4000A | HARMONIC filter |
| 79 | 14-80028D01 | INSULATOR, harmonic filter |
| 80 | 26-80283C01 | SHIELD directional coupler |
| 81 | 29-83897M01 | TERMINAL, wire receptacle; 2 used |
| 82 | 55-80107B01 | HANDLE |
| 83 | 7 80152B01 | BRACKET handle pivot 2 used |
| 84 | 22-84491M01 | PIN locking |
| 85 | 2 80006A01 | NUT spanner |
| 86 | 4 114522 | WASHER lock 5/8 internal |
| 87 | 32 80936A01 | GASKET ring |
| 88 | HLN4241A | ANTENNA SWITCH |
| 89 | 38 80154B01 | BUTTON cover release |
| 90 | 41 80155B01 | SPRING cover release |
| 91 | 42 81106B01 | RETAINER ring |
| 92 | 5 80155B01 | CATCH cover release |
| 93 | 75 84882E | BUMPER rubber |
| 94 | 3 1090 1875 | SCREW machine M5 x 0 8 x 16 mm 2 used |
| 95 | 55-84410B01 | LOCK with key |
| 96 | 15 83896B01 | HOUSING lock |
| 97 | 55-80161B01 | CATCH lock |
| 98 | 41 80156B01 | SPRING lock |
| 99 | 15 80114B01 | COVER button |
| 100 | 15 84764M01 | HOUSING radio |
| 101 | 28 82365D02 | CONNECTOR phono male |
| 102 | 4 80149A01 | WASHER flat private 4 used |
| 103 | 15-80106B01 | COVER top |
| 104 | 3 10905A05 | SCREW machine 3 0 x 0 5 x 8 mm 11 used |
| 105 | 3 10943C20 | SCREW tapping 3 0 x 0 5 x 8 mm 2 used |
| 106 | — | NOT USED |
| 107 | HLD4116A | CIRCUIT BOARD power amplifier |
| 108 | HLN4247A | I P A |
| 109 | 42 84367M01 | CLIP wire hold down 2 used |
| 110 | HLN4256A | ATTENUATOR switch |
| 111 | 42 84881E01 | CLIP hold down |
| 112 | 2 7003 | NUT stud mounting 2 used |
| 113 | 32 80219B01 | GASKET front connector |
| 114 | 1 80708T31 | FRONT CONNECTOR ASSEMBLY male 37 contact |
| 115 | 28 82647K02 | CONNECTOR male 10 contact 2 used |
| 116 | 28 83603M01 | CONNECTOR male 20 contact |
| 117 | 9 84207B01 | SOCKET metering 7 contact 2 used |
| 118 | 9 83445L09 | CONNECTOR female 10 contact |
| 119 | 30 83602M01 | CABLE conductor (includes P401) |
| 120 | 28 80052D01 | CONNECTOR right angle 10 contact |
| 121 | 28 82622L03 | CONNECTOR male 22 contact |
| 122 | 9 83729M01 | SOCKET 7 contact |
| 123 | 4 84152B01 | WASHER shoulder |
| 124 | 14 83820M02 | INSULATOR transistor 5 used |
| 125 | 26 83498M01 | HEATSINK audio PA |
| 126 | 15 84301K01 | HOUSING connector 3 contact |
| 127 | 4 84180C01 | WASHER shoulder 5 used |
| 128A | 15 84301K16 | HOUSING connector 2 contact |
| 128B | 39 82717M01 | CONTACT receptacle 2 used |
| 129 | 55 84300B04 | HANDLE PA shield |
| 130 | 55 84300B03 | HANDLE short |
| 131 | HLN4270A | INTERFACE CIRCUIT BOARD |
| 132 | 2 10971A63 | NUT machine M3 5 x 0 6 |
| 133 | 43 80033B01 | STANDOFF (RF power board |
| 134 | 14 84690M01 | INSULATOR |
| 135 | 14 84690M02 | INSULATOR |
| 136 | 14 84691M01 | INSULATOR |
| 137 | 14 84691M02 | INSULATOR |
| 138 | 46 83821M01 | ALIGNMENT PIN memory module 2 used |
| 139 | 4 7652 | WASHER lock 5/16 split 2 used |
| 140 | 4 114136 | WASHER flat 0 142 x 0 250 x 046 3 used |
| — | — | non-referenced items |
| | 54-84342M01 | LABEL heating ground (mixer cover, VCO cover) 2 used |
| | 54 84126C01 | LABEL Motorola Rep Parts casting wall |
| | 54 84659M01 | LABEL patent buffer cover) |
| | 54 850440 | LABEL FCC |

*Exploded View, Mechanical Parts List, and Functional Block Diagram of SYNTOR X High Band Systems Radio (110 W/10 W) Motorola No. PEPS-32246-O (Sheet 1 of 2)*
*10 2 81- NPC*

# FUNCTIONAL BLOCK DIAGRAM OF RADIO




*Exploded View, Mechanical Parts List, and Functional Block Diagram of SYNTOR X High Band Systems Radio (110 W/10 W) Motorola No. PEPS-32246-O (Sheet 2 of 2) 10/2/81- NPC*

# SPECIAL REPAIR PROCEDURES

## 1. MICROSTRIP CERAMIC SUBSTRATES

1.1 Repair of the microstrip ceramic substrates of the radio is not recommended and, hence, should be avoided. Because of the critical nature of these circuits, the repair procedure should consist of replacing a defective module rather than a faulty component on a given module. The modules of the radio are built and tested at the factory employing special fixtures to insure proper operation of these modules.

1.2 Soldering to microstrip ceramic modules should be done with as little heat or pressure as is practical. The ceramic materials of the radio have properties that are similar to those of glass, i.e., they can be damaged by sharp blows or excessive heat. Solder with high percentage of silver should be used, to avoid leaching the capacitors or non-copper runners.

## 2. CHIP CAPACITORS

2.1 The radio employs many chip capacitors as circuit elements. These capacitors are extremely sensitive to heat and must not be re-used. Repairs to circuits near these components should be performed with care; heat, as from a soldering iron on a nearby component, may cause the capacitor end metalization (terminals) to "leach". Refer to Figure 1 for an example of a leached capacitor.

2.2 Chip capacitors must be removed by applying heat to both connecting terminals simultaneously and lifting when the connecting solder melts. This may be accomplished with two soldering irons or with a single iron using a special tip (Motorola Part No. ST-1160). Refer to Figures 2 and 3 for examples of this removal technique.

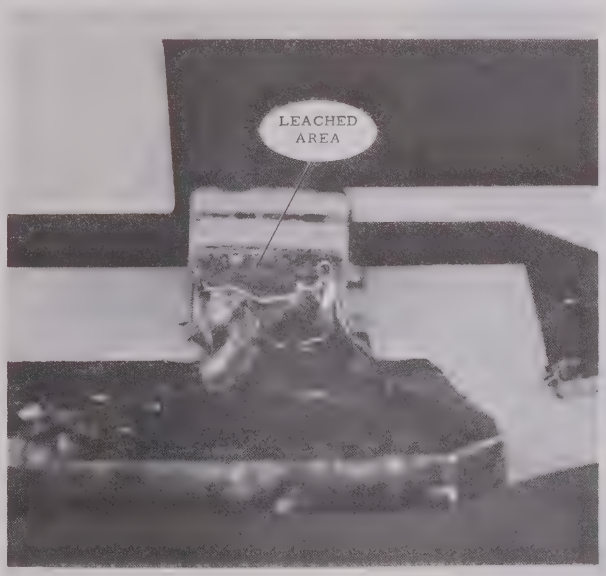



*Figure 1.*
*Example of "Leached" Chip Capacitor*



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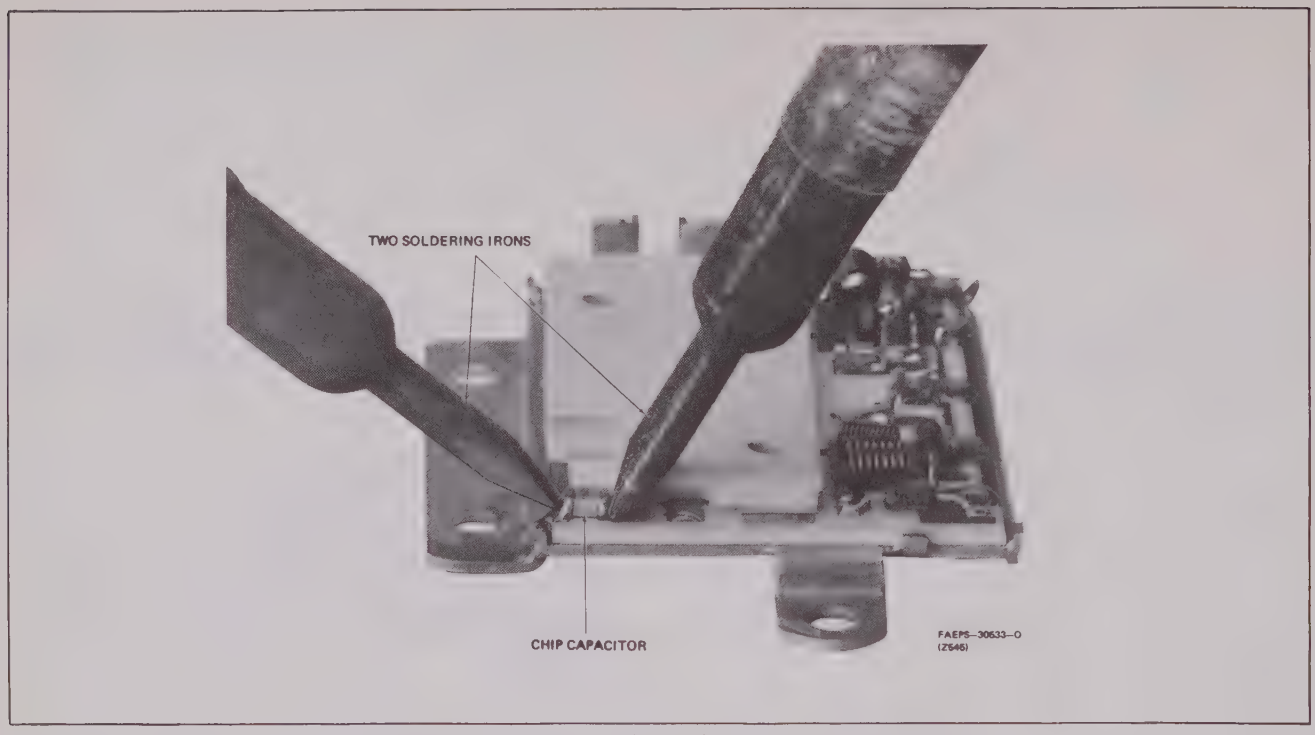



*Figure 2.*
*Removal of Chip Capacitors with Two Soldering Irons*

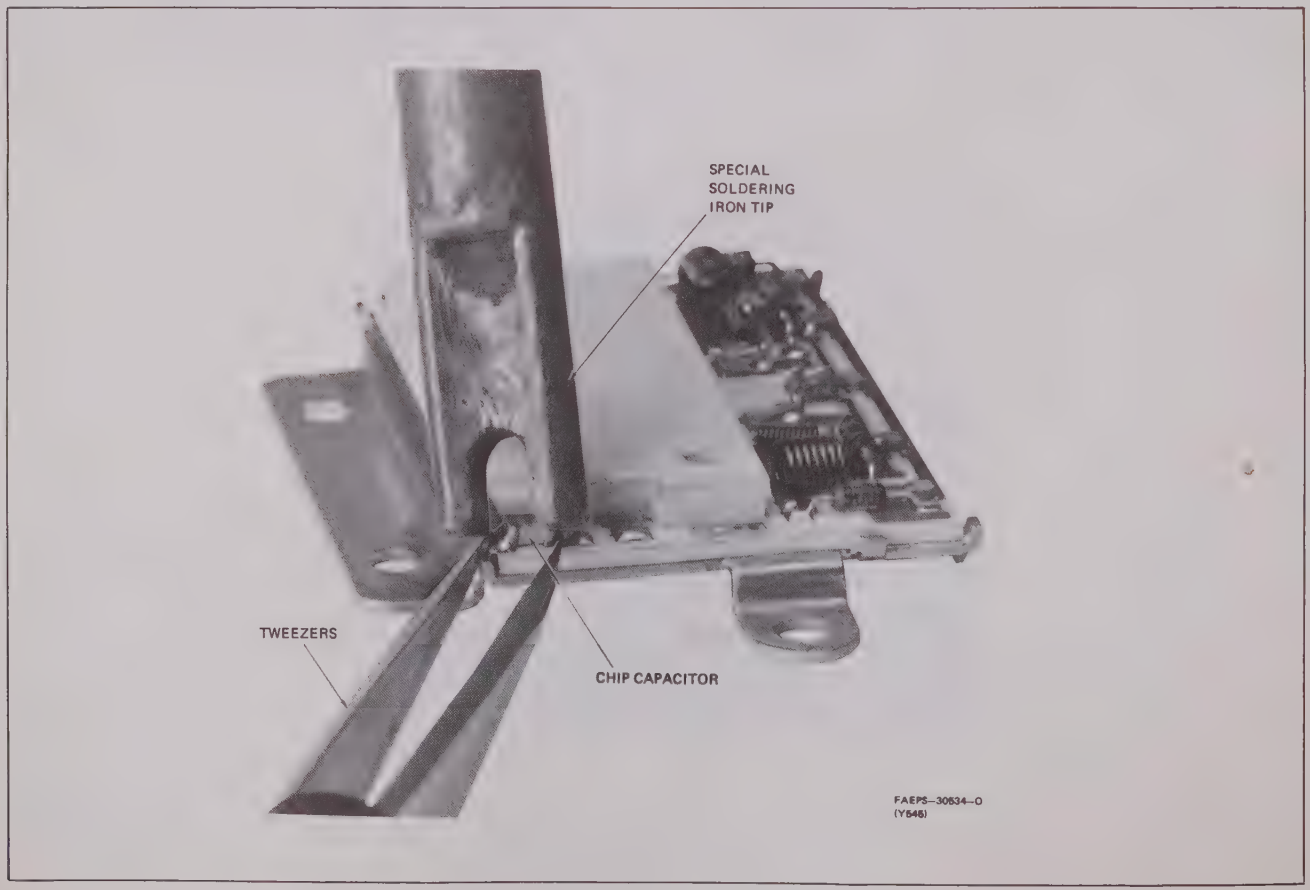



*Figure 3.*
*Removal of Chip Capacitor with Special Soldering Iron Tip*

## 3. POWER AMPLIFIER TRANSISTOR REPLACEMENT

3.1 To remove the power transistors, remove two transistor mounting screws, or one stud nut (accessible from the chassis bottom). Unsolder and remove the clamped mica capacitors, unsolder, and remove the transistors. (Special soldering iron tips ST1160 and ST1161 are available from the MOTOROLA parts department to aid in the capacitor and transistor removal.)

3.2 When replacing rf power transistors several precautions ***must*** be observed. First remove all thermal compound and residue from *both the chassis and the transistor* using a soft cloth or paper towel. Apply a thin film of Wakefield thermal compound to the bottom of the transistor mounting flange. Replace the transistor in the center of the printed circuit board cutout tightening the mounting hardware to 6-7 inch pounds ***maximum***. Solder leads using a low power (40-60 W) iron using enough solder to completely cover the lead and solder pad. ***Make sure*** that the solder is flowing freely both *over* and *under* the lead before removing the heat. If a lead tends to spring away from the printed circuit board, hold down the far end of the lead against the board (using the tip of pliers) until the solder hardens. *Be sure* to replace the clamped mica capacitors in the *exact* original position with respect to the transistor body after replacing the transistors.

# MICROCOMPUTER SYSTEM

(PERSONALITY BOARD, MEMORY MODULE, AND I/O BOARD)

## 1. GENERAL DESCRIPTION

1.1 Most major functional blocks of the *SYNTOR X* radio are directly controlled by the microcomputer system. In addition, the microcomputer system performs the following functions that are available with the *SYNTOR X* radio: PL/DPL encode/decode, *Channel Scan*, and time-out timer. The system employs a single-chip, 8-bit, 40-pin microcomputer.

1.2 The microcomputer system circuits are located on the HLN4257A Personality Board. The personality board also includes the receive audio circuits of the radio. This board is accessible from the top of the radio. Disassembly information on the personality board, memory module, and I/O board is provided in the General Maintenance/Troubleshooting section of this manual.

## 2. THEORY OF OPERATION

### 2.1 INTRODUCTION

The microcomputer (U8) requires two major inputs in order to operate: a +5 V input voltage ($V_{CC}$ at U8-40) and a clock source (CLOCK at U8-1 and U8-2). Proper filtering for the +5 V input voltage is provided by L2, C10, and C11. The clock source is a 3.6000 MHz, fundamental-mode, parallel resonant quartz crystal that is connected, via U8-1 and U8-2, to the internal oscillator circuitry of the microcomputer. This arrangement permits the generation of a 2 V peak-to-peak (approximately) sinusoidal waveform at U8-2.

### 2.2 MEMORY MODULE

2.2.1 A memory module provides the microcomputer with the information it requires to determine the operational characteristics of the radio. The memory module contains a PROM (programmable read-only memory) that is custom-programmed at the factory in accordance with the customer's specifications. The information contained within the memory module is specified by the mode label located on the transmitter power amplifier cover.

2.2.2 The microcomputer accesses the memory module whenever it requires new programming information to control its operation. This information may, for example, be associated with a status change generated when the mode selector switch on the control head is set to a different position, or it may be associated with the request to continue performing an internal program such as a channel scan.

2.2.3 The memory module is activated when the $\overline{\text{ENABLE}}$ signal at J99-21 goes low, and it stays activated as long as this signal is low. However, the microcomputer's access to the memory module is inhibited when the $\overline{\text{ENABLE}}$ signal switches to a high state. The memory module address (AØ through A9) are routed via pins 16, 15, 14, 13, 12, 11, 10, 9, 2, 1 of J99, whereas the data signals (D through D7) are routed via pins 20, 19, 18, 17, 5, 6, 7, 8 of J99.

### 2.3 MULTIPLEXER OUTPUT DATA LATCH (U2)

2.3.1 The additional input and output lines required by the microcomputer are provided by the multiplexer output data latch (U2) and the input multiplexer (U3). U2, a CMOS device, provides the audio control data and transmit power control. The address lines of U2 are provided at U8-3, U8-4, and U8-5, whereas the programming data for U2 is provided at U8-6. An active-low latching pulse ($\overline{\text{OUTPUT LATCH WRITE}}$) is provided at U8-33 and is applied to U2-4.

2.3.2 U2 provides the following output signals: (a) ALERT TONE (U2-11); (b) PL/DPL FILTER SELECT (U2-12) which is routed to the I/O board to determine the filter input characteristics; (c) XMIT POWER CONTROL (U2-13) which, when held low, provides a low power output; (d) $\overline{\text{PRIORITY SAMPLE MUTE}}$ (U2-14) which controls the priority sample mute switch that provides fast response times during channel scan operation; and (e) $\overline{\text{MUTE}}$ (U2-15) which controls the standard audio mute shunt switch.

## 2.4 INPUT MULTIPLEXER (U3)

2.4.1 U3, a CMOS device, is an 8-bit-to-1-bit programmable data selector that constitutes the second portion of the microcomputer's I/O expander circuitry. U3 is controlled by three address lines (A0, A1, A2) which are applied to U3-11, U3-12, and U3-13 from U8-3, U8-4, and U8-5, respectively. U3 provides a single data output (U3-14) that is applied to pin 38 of the microcomputer [MUX INPUT DATA (INTERRUPT].

2.4.2 U3 receives both internal and external signals as inputs. The external control signals, which come from the control cable, are protected by 10-kilohm resistors which form part of the hybrid 1 (HY1) circuit. The input signals consist of: (a) SYN SYNC (synthesizer synchronism) line (U3-1); (b) SQUELCH TAIL line (U3-3) which comes in from the squelch circuitry and is protected by pull-down resistor R22; (c) fast-responding, active-high CHANNEL ACTIVITY line (U3-4) which comes from the squelch circuit and is protected by pull-up resistor R21; (d) CHANNEL SCAN ENABLE line which comes from the control head at J1-31 and is applied to U3-5; (d) PL/DPL DISABLE line which comes from J1-32 and is applied to U3-6; and (f) DISPLAY ENABLE line which is provided at J1-33 and is applied to U3-7.

## 2.5 PTT LINE

The remaining signals that are brought in from the control cable to permit the radio to operate are the PTT line and the mode switch contents. The PTT line is applied to a dual opto-isolator (U1) via J1-4. U1 combines the PTT signal with the ignition battery line (PTT REF at J1-5) to provide an ISOLATED PTT signal to U3-26. This is a low-active signal that occurs only when both the PTT and ignition lines are active. In the absence of transmission, this signal is pulled to regulated 9.6 V by 47-kilohm resistor R4. (This circuit is also compatible with positive-ground operation.)

## 2.6 MODE SWITCHING

2.6.1 The mode switch setting inputs are routed to the microcomputer via four integrated devices (U4, U5, U6, U7) wired in a configuration that provides 12 microcomputer-controlled bidirectional lines. These 12 bidirectional lines are arranged into two microcomputer-controlled arrays: the first consisting of 4 lines, and the other of 8 lines. The 4-line array is connected to mode lines 9, 10, 11, and 12, whereas the second array (the 8-line array) is connected to mode lines 1 through 8. U4 and U6 are used to buffer the signals from the control head.

2.6.2 U4 and U6 are each provided with a three-state control line for four of six buffers and with a different three-state control line for the remaining two buffers. These CMOS buffers are of the non-inverting type. The U4 and U6 inputs are protected by 10-kilohm resistors when they are connected to mode lines 1 through 12. These protective resistors form part of hybrid circuits 2 through 4 (HY2 through HY4). Mode lines 1, 2, 3, 4, 9, and 10 are buffered by U4, whereas mode lines 5, 6, 7, 8, 11 and 12 are buffered by U6.

2.6.3 U5 and U7 provide drive capability on mode lines 1 through 12 to allow the microcomputer to write data into latches in the control head. U5 and U7 (which are non-inverting, tristable hex buffer TTL devices) are arranged into a configuration so that four of the buffers are controlled by one three-state line and the two remaining buffers are controlled by a different three-state line. Mode lines 1, 2, 3, 4, 9, and 10 are controlled by U5, whereas mode lines 5, 6, 7, 8, 11 and 12 are controlled by U7. Buffered mode lines 1 through 8 are connected to pins 8 through 15 of the microcomputer, whereas buffered mode lines 9 through 12 are connected to pins 22 through 25 of the microcomputer.

2.6.4 The three-state control lines for U4, U5, U6, and U7 are provided at pins 34, 35, 36 and 37 of U8. The signal at U8-34 controls the input sections of U4 and U6 buffering mode lines 9-12; the signal at U8-36 controls the input sections of U4 and U6 buffering mode lines 1-8; and the signal at U8-35 controls the output sections of U5 and U7 buffering mode lines 9-12; the signal at U8-37 controls the output section of U5 and U7 buffering mode lines 1-8. The signal at U8-35 is also buffered by Q1, R2 and R3 and is provided via J1-1, as a CONTROL HEAD STROBE signal to the control head.

2.6.5 Mode lines 9 through 12 of the bidirectional bus act as an address system when the CONTROL HEAD STROBE signal is acting as chip enable and mode lines 1 through 8 are acting as bidirectional data bus.

## 2.7 FREQUENCY SYNTHESIZER

The microcomputer is used to program the synthesizer divider (U602) to provide the correct operating carrier frequency for the radio. This is achieved by connecting three address lines between pins 12, 13, and 14 of the microcomputer and pins 7, 8, and 5 of P602 (SYN AØ, SYN A1, SYN A2, respectively). A low-active line ($\overline{\text{STROBE}}$) is generated at U8-7 and routed to the synthesizer via P601-4 to provide a latching pulse for each programming data word to the synthesizer. This line is then inverted by Q7, R19, and R20 to provide a high-active synthesizer strobe (SYN STROBE) line (at P601-4). A wired logic configuration exists between the collector of Q7 and U8-31. Consequently, a high logic output will occur whenever the signal at U8-7 ($\overline{\text{STROBE}}$) is low and the signal at U8-31 (SYNTHESIZER ENABLE) is high. The SYN STROBE signal is repetitively sent to the synthesizer whenever it is being refreshed by the microcomputer system. This signal is also routed to the activity monitor circuit of the microcomputer.

## 2.8 MICROCOMPUTER ACTIVITY MONITOR

The microcomputer activity monitor circuit consists of U9 (a dual CMOS resettable monostable device) and associated resistors (R24 thru R29), capacitors (C12 thru C14), and diodes CR3, CR4, and CR5. The SYN STROBE signal is applied to U9A-4 at a maximum of approximately 10-millisecond intervals, thus resetting the monostable and keeping it reset. As long as the monostable is reset within its 33-millisecond time constant, its output at U9A-7 remains low, thus allowing the microcomputer to operate. If the strobe pulse is missed and the 33-millisecond time constant runs out, the monostable output switches to a high state, thus causing the second monostable (U9B) to enter into an oscillatory mode. Under such conditions, U9B provides an output that is high for approximately 34.5 milliseconds and low for approximately 4.7 milliseconds. This signal, generated at U9B-9, is routed to U8-39, where as an active-low RESET line it causes the microcomputer to reset and to start its operation all over again. The time constants are controlled by the following RC pairs: (a) R25/C12, 33 ms, (b) R28/C14 4.7 ms, and (c) R27/R29/C13, 34.5 ms.

## 2.9 TRANSMITTER

The microcomputer provides the transmitter with two control lines: KEYED 9.4 V ENABLE (U8-30) and XMIT PA ENABLE (U8-32). The keyed 9.4 V enable signal is activated when it switches to a low state. This signal is applied to the keyed 9.4 V switch circuit which inverts the signal and applies a KEYED 9.4 V signal to P601-1 and J401-8. The 9.4 V switch circuit is a quasi Darlington circuit comprising Q4 and Q3 and associated components. The XMIT PA ENABLE signal is generated at U8-32, buffered by the PA enable switch (Q5 and Q6 and associated components), and provided as a low-active signal (PA ENABLE) to the power control circuitry in the common circuits board via J401-10. If the synthesizer is in the adapt mode, or the output of the microcomputer activity monitor circuit at U9-7 is high, R26, R14, and R15 will buffer the signals from either device, thus causing the output of Q5 to go low and inhibit the PA ENABLE signal.

## 2.10 I/O BOARD

2.10.1 The analog-to-digital and digital-to-analog signal conversion for the microcomputer system is performed by the I/O board. The I/O board can functionally be divided into two parts: an analog-to-digital section and a digital-to-analog section.

2.10.2 The analog-to-digital section consists of a low pass filter that acts on the detected audio (DET AUDIO) signal it receives from P51-4. This low-pass filter is controlled by the PL/DPL SELECT line that is routed via P51-1. In the PL state, the filter is a 5-pole, half-dB ripple Chebyshev filter with a 245-Hz cutoff. In the DPL condition, it behaves like a 3-pole Butterworth filter with a 140 Hz cutoff. The output of the low-pass filter is applied to the limiter circuit (U54 and associated components). The limiter cicuit provides a 0-to-5 V digital signal (REC PL/DPL) that is applied via P51-2 to pin 27 of the microcomputer.

2.10.3 The digital-to-analog section consists of a resistive lattice network that receives four digital signals from the microcomputer via P51-5, P51-6, P51-10, and P51-9 (PL3, PL2, PL1, and PL0, respectively). The digital-to-analog circuit provides an output that is applied to a 3-pole, Butterworth low-pass filter with a 300 Hz cutoff. The filter's output (XMIT PL/DPL) is forwarded to the IDC on the common circuits board via P51-11 and J401-3.

# 3. TROUBLESHOOTING PROCEDURE

## 3.1 INTRODUCTION

The troubleshooting procedures presented in this section of the manual consist of the following:

- microcomputer system troubleshooting procedure
- microcomputer (U8) troubleshooting procedure
- mode information troubleshooting procedure
- diagnostic aid mode procedure.

## 3.2 REQUIRED TEST EQUIPMENT

The following test equipment will be required:

- oscilloscope
- high-band rf signal generator
- voltmeter
- test memory module.

Refer to the list of recommended test equipment provided in the GENERAL MAINTENANCE/ TROUBLESHOOTING section in the manual.

## 3.3 MICROCOMPUTER SYSTEM TROUBLESHOOTING GUIDE

3.3.1 Refer to the microcomputer system troubleshooting guide located at the end of this section. This chart contains the following four procedures:

(a) no receive audio

(b) radio does not squelch

(c) no PL/DPL modulation output

(d) no (or low) rf output power.

This chart also contains the microcomputer (U8) troubleshooting procedure, described below.

3.3.2 It is assumed that you have been referred to the microcomputer system troubleshooting procedure via the general system troubleshooting guide

located in the GENERAL MAINTENANCE/ TROUBLESHOOTING section in this manual. In the general system troubleshooting guide, the following symptoms lead you to the microcomputer system troubleshooting guide.

1. no receive audio
2. radio does not squelch
3. radio does not unsquelch
4. no PL/DPL encode
5. no rf power output.

For symptoms (1) and (3), refer to the no receive audio procedure of the microcomputer system troubleshooting guide; for symptom (2), refer to the radio does not squelch procedure: for symptom (4) refer to the no PL/DPL modulation output procedure; and for symptom (5), refer to the no (or low) rf power output procedure.

3.3.3 In the four procedures (a), (b), (c), and (d), reference is made to the following procedures:

- synthesizer troubleshooting chart; this chart is located in the SYNTHESIZER section of this manual.
- squelch troubleshooting chart; this chart is located in the COMMON CIRCUITS BOARD section of this manual.
- audio troubleshooting; refer to the voltages and waveforms on the audio schematic diagram located in the MICROCOMPUTER SYSTEM section of this manual.
- microcomputer (U8) troubleshooting chart; this is included in the microcomputer system troubleshooting procedure.
- IDC troubleshooting; refer to the IDC portion of the synthesizer troubleshooting chart.
- power control troubleshooting chart; this chart is located in the TRANSMITTER section of this manual.
- mode information troubleshooting procedure; this procedure is located in this section of the manual.

## 3.4 MICROCOMPUTER (U8) TROUBLESHOOTING GUIDE

3.4.1 This procedure is normally arrived at via one of the four procedures associated with the microcomputer system troubleshooting guide. The microcomputer (U8) troubleshooting chart forms part of the microcomputer system troubleshooting procedure, located at the end of this section.

3.4.2 This procedure, in turn, makes reference to the following prcedures:

- regulator troubleshooting procedure located in the COMMON CIRCUITS BOARD section of the manual.
- synthesizer troubleshooting chart located in the SYNTHESIZER section of this manual.
- mode information troubleshooting procedure located in this section (see below).
- diagnostic aid mode chart located at the end of this section.

3.4.3 Before starting the microcomputer (U8) troubleshooting procedure, verify that the memory module serial number (excluding the suffixes) matches the radio serial number. Symptoms of incorrect memory module information include the following:

(1) synthesizer will not lock on one or more modes: this is indicated by the red LED indicator on the rf board staying lit and the audio failing to unmute.

(2) synthesizer locks on an rf frequency but the audio will not unmute because of wrong PL or DPL information.

**NOTE**

If the radio is in a channel scan mode and does not detect channel activity, the synthesizer red lock LED indicator (on the rf board) will appear to be continuously lit. If the synthesizer is operating properly, the lock indicator can be turned off by unsquelching the radio.

## 3.5 MODE INFORMATION TROUBLE- TROUBLESHOOTING GUIDE

### 3.5.1 Introduction

3.5.1.1 This troubleshooting procedure is arrived at via the general system troubleshooting guide, the microcomputer system troubleshooting procedure, or via the microcomputer (U8) troubleshooting procedure. At this point, it has been established that the radio is receiving properly but that the microcomputer is apparently accessing the wrong block of mode information in the memory module. This would also result in an incorrect receive frequency unless, by chance, the two blocks of mode information are programmed for the same receive frequency.

3.5.1.2 The problems may be caused by any one of the following conditions, listed in their order of priority:

(1) faulty cable interface ICs (U4, U5, U6, U7).

(2) faulty cable wiring or faulty control head operation, causing incorrect reading of the mode switch by the microcomputer.

(3) use of the wrong memory module

(4) faulty memory module.

3.5.2 Faulty Cable Interface ICs

The cable interface ICs (U4, U5, U6, U7); can be checked by using the diagnostic aid mode procedure located at the end of this section.

**NOTE**

This procedure assumes that the control group is the one described in 3.5.3.1, case (1), below.

3.5.3 Faulty Cable Wiring or Faulty Control Head Operation

3.5.3.1 In this case, the mode information supplied to the microcomputer is presented to the cable reading ICs (U4 and U6). Two cases are possible:

(1) the control group consists of a rotary mode select (8 modes).

(2a) the control group consists of an alternate control module with or without talk-around but with 8-mode pushbutton operator mode select option.

(2b) the control group has a mode select with scan lights option (all on a single printed circuit board).

(2c) the control group consists of rotary mode select of 16 or more modes.

3.5.3.2 For case (1), the mode information is presented to the radio by grounding one and only one of the 12 mode lines in the cable, connected to pins 13, 17, 24, 25, 12, 26, 23, 29, 26 19, 30, and 11 (modes 1 through 12, respectively) of the radio front plug (J1).

3.5.3.3 For cases (2a), (2b), and (2c), the mode information is presented to the radio in binary-encoded format on the lower six mode lines of the cable (pins 13, 17, 24, 25, 12, and 16 of the radio front plug. J1) with mode lines 7 and 8 (J1-23 and J-29) grounded.

3.5.3.4 In all cases, if the ordered options require transmission of data, the mode information is placed on the twelve mode lines only when the microcomputer requests mode information by generating low-level voltage (approximately 0.2 V) on U8-34, thus turning Q1 off and driving the CONTROL HEAD STROBE line high (approximately 2.2 V) (at J1-1). Data transmission required by options include: (a) lights information other than mode, (b) switch banks addresses, and (c) data reading from options such as an operator-select coded squelch switch closure, or an operator-select *Channel Scan* switch closure.

3.5.4 Use of Wrong Memory Module

In this case, the serial number of the memory module should be checked against the serial number of the radio.

**NOTE**

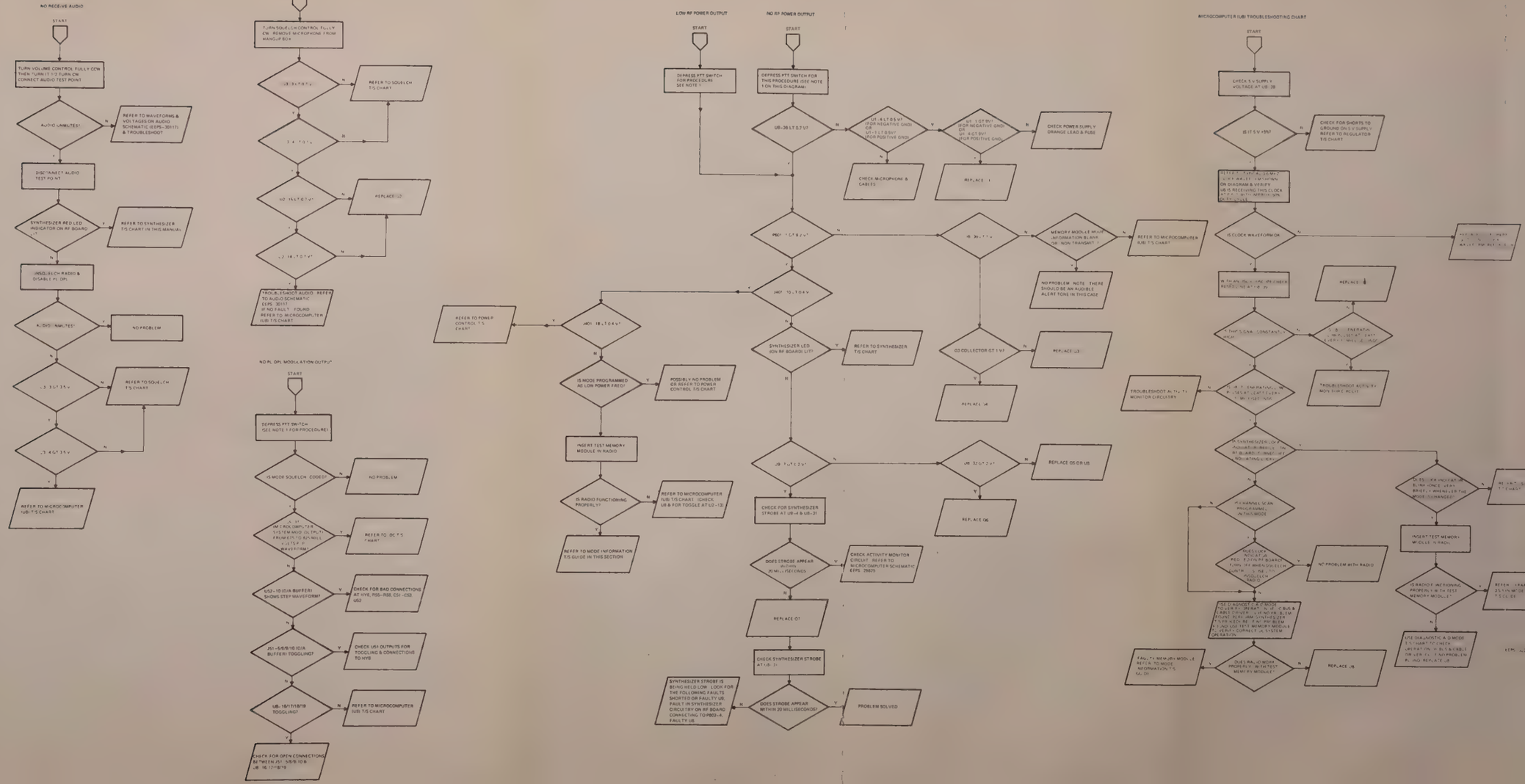
If *Systems 90•S* options are purchased some time after the initial purchase of a *SYNTOR X* mobile radio, a new memory module is often required; in this case a suffix letter is changed on the memory module serial number. Earlier suffix versions of the memory module may no longer be usable once the newly purchased options have been wired into the system. The memory module initially shipped with the radio includes information for the proper operaton of all the options that were simultanously purchased with the radio.

3.5.5 Faulty Memory Module

In this case, a replacement memory module should be purchased from an authorized Motorola Representative. Since Motorola maintains a record of the information assocated with the memory module purchased by customers, correctly-programmed replacement memory module can be provided by Motorola even if the customer cannot locate the original order information sheet. However, conditions (1) and (2), described above, should be checked before assuming that the memory module is faulty. (Refer to the procedures: Faulty Cable Interface ICs, and Faulty Cable Wiring or Faulty Control Head Operation.)

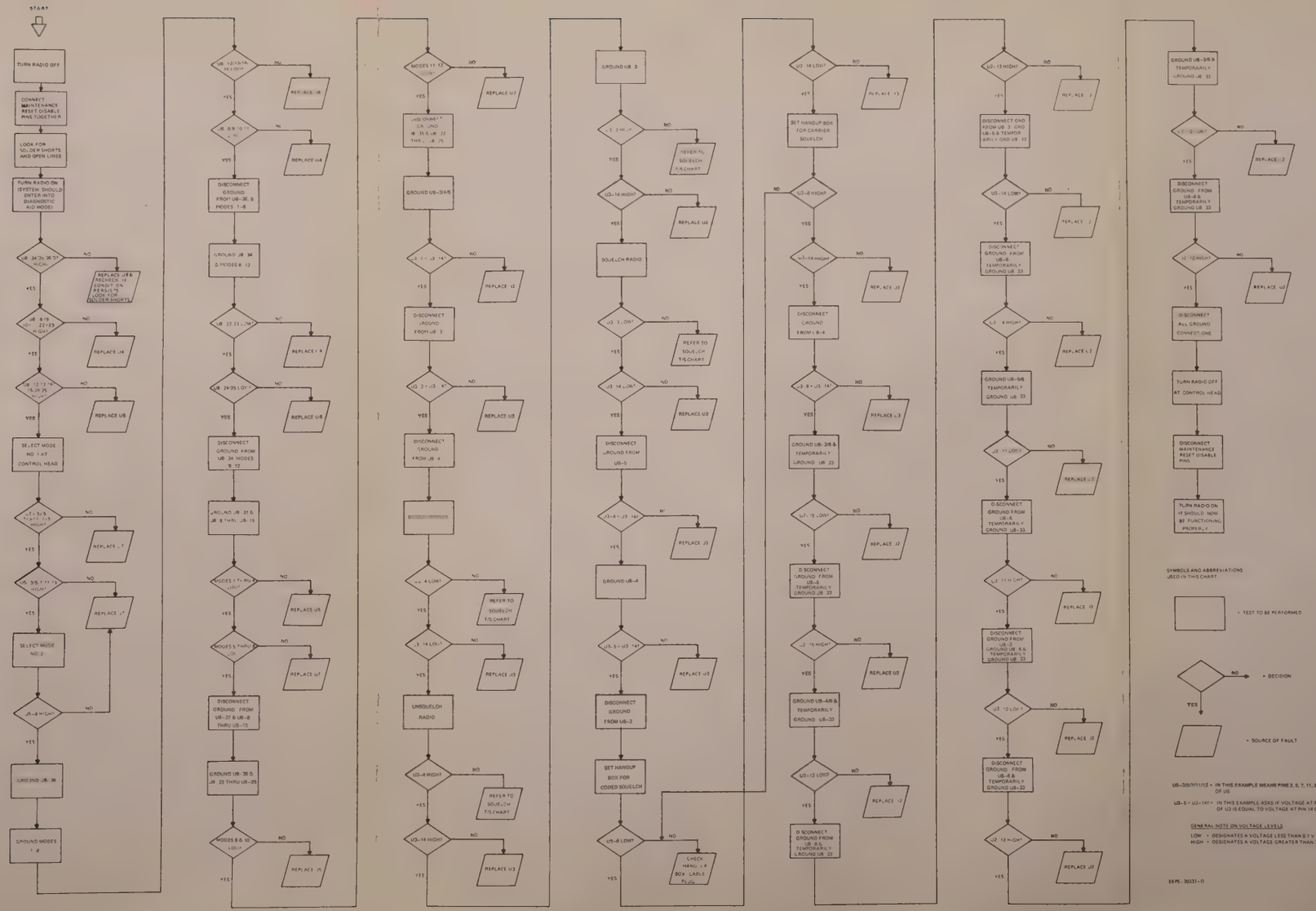
## 3.6 DIAGNOSTIC AID MODE PROCEDURE

Refer to the diagnostic aid mode flowchart located at the end of this section. This procedure is arrived at via (a) the microcomputer (U8) troubleshooting chart, or (b) via the faulty cable interface ICs procedure that forms part of the mode information troubleshooting guide.


NO RECEIVE AUDIO
START
TURN VOLUME CONTROL FULLY CCW THEN TURN IT 1/2 TURN CW CONNECT AUDIO TEST POINT
AUDIO UNMUTES?
REFER TO WAVEFORMS & VOLTAGES ON AUDIO SCHEMATIC (EEPS-30117) & TROUBLESHOOT
DISCONNECT AUDIO TEST POINT
SYNTHESIZER RED LED INDICATOR ON RF BOARD
REFER TO SYNTHESIZER T/S CHART IN THIS MANUAL
UNSQUELCH RADIO & DISABLE PL DPL
AUDIO UNMUTES?
NO PROBLEM
REFER TO SQUELCH T/S CHART
REFER TO MICROCOMPUTER (U8) T/S CHART
RADIO DOES NOT SQUELCH
START
TURN SQUELCH CONTROL FULLY CW - REMOVE MICROPHONE FROM HANDSET
REFER TO SQUELCH T/S CHART
REPLACE U2
PROBLEM/SHOOT AUDIO - REFER TO AUDIO SCHEMATIC (EEPS-30117) IF NO FAULT FOUND REFER TO MICROCOMPUTER (U8) T/S CHART
NO PL DPL MODULATION OUTPUT
START
DEPRESS PTT SWITCH (SEE NOTE 1 FOR PROCEDURE)
IS MODE SQUELCH CODED?
NO PROBLEM
REFER TO DC T/S CHART
CHECK FOR BAD CONNECTIONS AT HYB, R56-R58, C51-C53, U53
CHECK U51 OUTPUTS FOR TOGGLING & CONNECTIONS TO HYB
REFER TO MICROCOMPUTER (U8) T/S CHART
CHECK FOR OPEN CONNECTIONS BETWEEN J51 5/8/9/10 & U8 16/17/18/19
LOW RF POWER OUTPUT
START
DEPRESS PTT SWITCH FOR PROCEDURE SEE NOTE 1
REFER TO POWER CONTROL T/S CHART
IS MODE PROGRAMMED AS LOW POWER FIXED?
POSSIBLY NO PROBLEM OR REFER TO POWER CONTROL T/S CHART
INSERT TEST MEMORY MODULE IN RADIO
IS RADIO FUNCTIONING PROPERLY?
REFER TO MICROCOMPUTER (U8) T/S CHART - CHECK U8 & FOR TOGGLE AT U2-13
REFER TO MODE INFORMATION T/S GUIDE IN THIS SECTION
NO RF POWER OUTPUT
START
DEPRESS PTT SWITCH FOR THIS PROCEDURE (SEE NOTE 1 ON THIS DIAGRAM)
U8-38 LT 0.7 V?
U1-4 LT 0.5 V? (FOR NEGATIVE GND) OR U1-11 LT 0.5V? (FOR POSITIVE GND)
CHECK MICROPHONE & CABLES
U1-11 GT 7.0V? (FOR NEGATIVE GND) OR U1-4 GT 8V? (FOR POSITIVE GND)
REPLACE 1
CHECK POWER SUPPLY ORANGE LEAD & FUSE
P601 GT 6.9 V?
J401 10 LT 0.4 V
J401 18 LT 0.4 V?
SYNTHESIZER LED (ON RF BOARD) LIT?
REFER TO SYNTHESIZER T/S CHART
U9 7 V? GT 2 V?
CHECK FOR SYNTHESIZER STROBE AT U8-4 & U8-31
DOES STROBE APPEAR (w/ Freq 20 MILLISECONDS
CHECK ACTIVITY MONITOR CIRCUIT. REFER TO MICROCOMPUTER SCHEMATIC EEPS-29870
REPLACE Q7
CHECK SYNTHESIZER STROBE AT U8-31
SYNTHESIZER STROBE IS BEING HELD LOW. LOOK FOR THE FOLLOWING FAULTS SHORTED OR FAULTY U8; FAULT IN SYNTHESIZER CIRCUITRY ON RF BOARD CONNECTING TO P802-4; FAULTY U8
DOES STROBE APPEAR WITHIN 20 MILLISECONDS?
PROBLEM SOLVED
R 30 T ? V
MEMORY MODULE W/ INFORMATION BLANK OR NON-TRANSMIT ?
REFER TO MICROCOMPUTER (U8) T/S CHART
NO PROBLEM NOTE THERE SHOULD BE AN AUDIBLE ALERT TONE IN THIS CASE
Q3 COLLECTOR GT 1 V?
REPLACE 3
REPLACE J4
U8 32 GT 2 V?
REPLACE Q5 OR U8
REPLACE Q6
MICROCOMPUTER (U8) TROUBLESHOOTING CHART
START
CHECK 5 V SUPPLY VOLTAGE AT U8-28
IS IT 5 V +5%?
CHECK FOR SHORTS TO GROUND ON 5 V SUPPLY REFER TO REGULATOR T/S CHART
REPLACE
TROUBLESHOOT ACTIVITY MONITOR CIRCUITRY
TROUBLESHOOT ACTIVITY MONITOR CIRCUIT
REFER TO SYNTHESIZER T/S CHART
INSERT TEST MEMORY MODULE IN RADIO
IS RADIO FUNCTIONING PROPERLY W TEST MEMORY MODULE?
REFER TO PARAGRAPH 2.5.1 IN MODE INFORMATION T/S GUIDE
NO PROBLEM WITH RADIO
REPLACE U8
FAULTY MEMORY MODULE REFER TO MODE INFORMATION T/S GUIDE
REPLACE



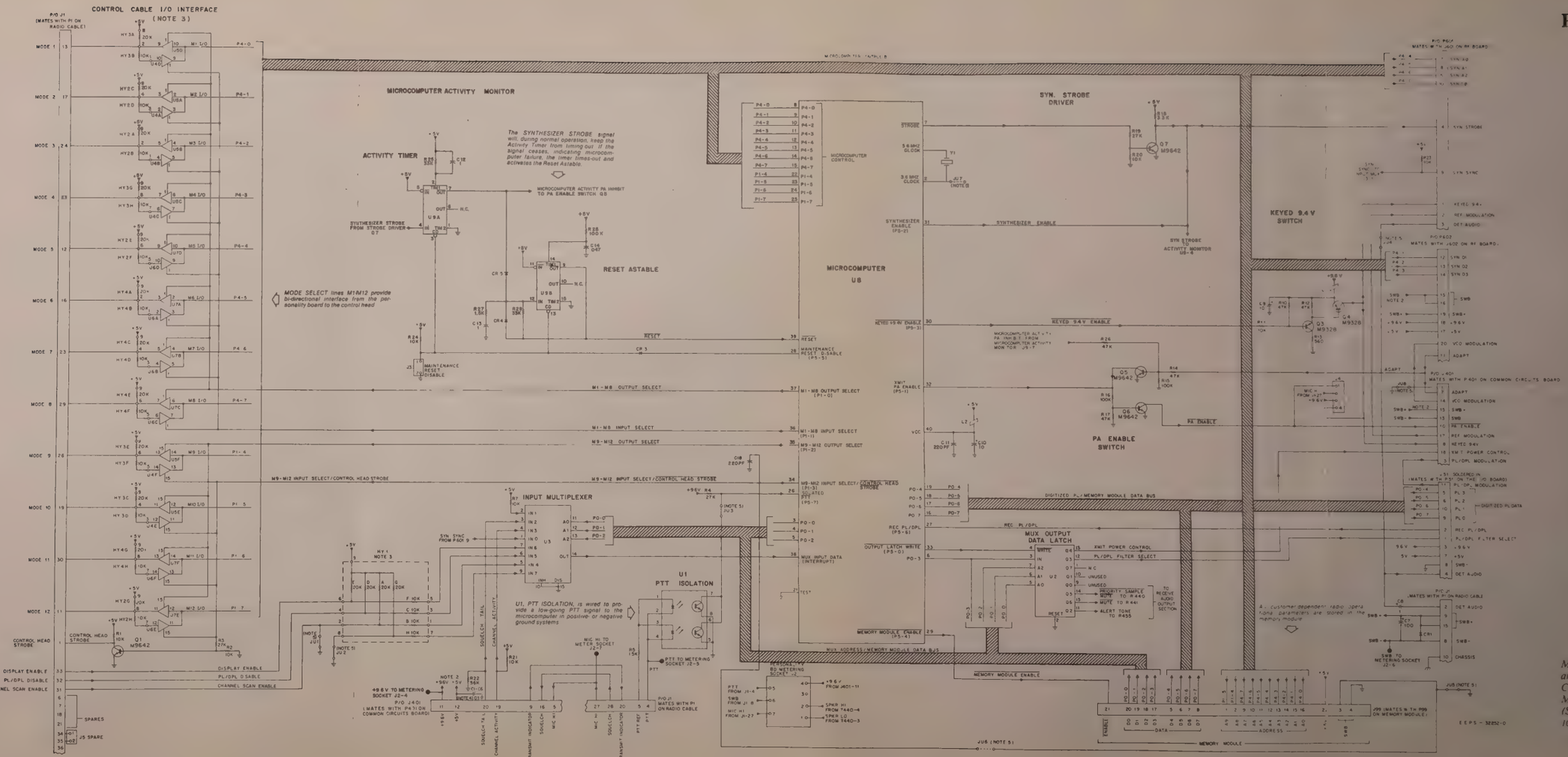
*Microcomputer System Troubleshooting Chart*
*Motorola No. EEPS-32250-O*
*10 2 81 NPC*


START
TURN RADIO OFF
CONNECT MAINTENANCE RESET DISABLE PINS TOGETHER
LOOK FOR SOLDER SHORTS AND OPEN LINES
TURN RADIO ON (SYSTEM SHOULD ENTER INTO DIAGNOSTIC AID MODE)
REPLACE U8 & RECHECK IF PROBLEM PERSISTS. LOOK FOR SOLDER SHORTS
REPLACE J4
REPLACE U8
SELECT MODE NO. 1 AT CONTROL HEAD
REPLACE J1
REPLACE J7
SELECT MODE NO. 2
GROUND UB-36
GROUND MODES 1-8
REPLACE J8
REPLACE J16
DISCONNECT GROUND FROM UB-35, & MODES 1-8
GROUND J8 34 & MODES 9-12
REPLACE J4
REPLACE U8
DISCONNECT GROUND FROM UB 34 MODES 9-12
GROUND J8 37 & J8 8 THRU J8-15
REPLACE U5
REPLACE U7
DISCONNECT GROUND FROM UB-37 & UB-8 THRU UB-15
GROUND UB-36 & J8 22 THRU UB-25
REPLACE J5
REPLACE U2
DISCONNECT GROUND FROM UB-3
REFER TO SQUELCH T/S CHART
REPLACE J3
UNSQUELCH RADIO
REPLACE U3
DISCONNECT GROUND FROM UB-4
REPLACE U3
DISCONNECT GROUND FROM UB-5
REPLACE J3
GROUND UB-4
REPLACE J3
DISCONNECT GROUND FROM UB-3
SET HANDUP BOX FOR CODED SQUELCH
CHECK HANDSET BOX CABLE PLUG
REPLACE U3
SET HANDUP BOX FOR CARRIER SQUELCH
REPLACE U3
DISCONNECT GROUND FROM UB-6
REPLACE J2
GROUND UB-3/8 & TEMPORARILY GROUND UB-33
REPLACE J3
DISCONNECT GROUND FROM UB-4
GROUND UB-4/8 & TEMPORARILY GROUND UB-33
REPLACE U2
DISCONNECT GROUND FROM UB-5
GROUND UB-5/8 & TEMPORARILY GROUND UB-33
REPLACE J2
DISCONNECT GROUND FROM UB-6
GROUND UB-6/8 & TEMPORARILY GROUND UB-33
REPLACE J2
DISCONNECT GROUND FROM UB-6
GROUND UB-5/8 TEMPORARILY GROUND UB-33
REPLACE J2
DISCONNECT GROUND FROM UB-5
GROUND UB-6/8 TEMPORARILY GROUND UB-33
REPLACE J3
DISCONNECT GROUND FROM UB-6
GROUND UB-3/8 & TEMPORARILY GROUND UB-33
REPLACE J2
DISCONNECT ALL GROUND CONNECTIONS
TURN RADIO OFF AT CONTROL HEAD
DISCONNECT MAINTENANCE RESET DISABLE PINS
TURN RADIO ON IT SHOULD NOW BE FUNCTIONING PROPERLY
SYMBOLS AND ABBREVIATIONS USED IN THIS CHART
= TEST TO BE PERFORMED
= DECISION
= SOURCE OF FAULT
U5-3/5/7/11/13 = IN THIS EXAMPLE MEANS PINS 3, 5, 7, 11, & 13 OF U5
U3-5 = U2-14? = IN THIS EXAMPLE ASKS IF VOLTAGE AT PIN 5 OF U3 IS EQUAL TO VOLTAGE AT PIN 14 OF U2
GENERAL NOTE ON VOLTAGE LEVELS
LOW = DESIGNATES A VOLTAGE LESS THAN 0.7 V
HIGH = DESIGNATES A VOLTAGE GREATER THAN 3.5 V
EEPS-30337-O

*Diagnostic Aid Mode Troubleshooting Chart*
*Motorola No. EEPS-30337-O*
*10/2/81- NPC*

# PERSONALITY BOARD

## SCHEMATIC DIAGRAM


CONTROL CABLE I/O INTERFACE (NOTE 3)
MICROCOMPUTER ACTIVITY MONITOR
ACTIVITY TIMER
RESET ASTABLE
MICROCOMPUTER U8
SYN. STROBE DRIVER
KEYED 9.4 V SWITCH
PA ENABLE SWITCH
INPUT MULTIPLEXER
MUX OUTPUT DATA LATCH
U1 PTT ISOLATION
MODE SELECT lines M1-M12 provide bi-directional interface from the personality board to the control head
U1, PTT ISOLATION, is wired to provide a low-going PTT signal to the microcomputer in positive- or negative ground systems
A customer-dependent radio operating parameters are stored in the memory module
MICROCOMPUTER SYSTEM

NOTES

1. Unless otherwise stated, resistor values are in ohms. A slash (/) between values are in microfarads. All inductor values are in microhenries.
2. The microcomputer and receive audio output sections of the personality board are shown on separate diagrams. The 5V, B+, 9.6 V supply and the Microcomputer Section diagram and the A+ and A- output connections are shown on the Receive Audio Out put Section Diagram.
3. Resistors labeled HY1-HY4 are part of four hybrid resistor networks. These resistors are not individually replaceable; the entire hybrid must be replaced if any resistor within the hybrid fails.
4. Capacitors C1 through C6 .01 uF 20%, disc capacitors, Motorola part no. 21S11015C05 are bypass capacitors for integrated circuits U2 through U7 respectively.
5. Refer to jumper table

Jumper Table

| Jumper | Normal Connection | Status/Function |
|---|---|---|
| JU1 | In | Out with Systems 90+S Channel Scan options |
| JU2 | In | Out to eliminate DPL turn-off code or PL reverse burst |
| JU3 | In | Out for special customer applications |
| JU4 | In | Out for special customer applications |
| JU5 | In | Out for ≥ 64-mode operation |
| JU6 | Out | In for ≥ 64-mode operation |
| JU7 | Out | — |
| JU8 | In | Out for special customer applications |

Integrated Circuits

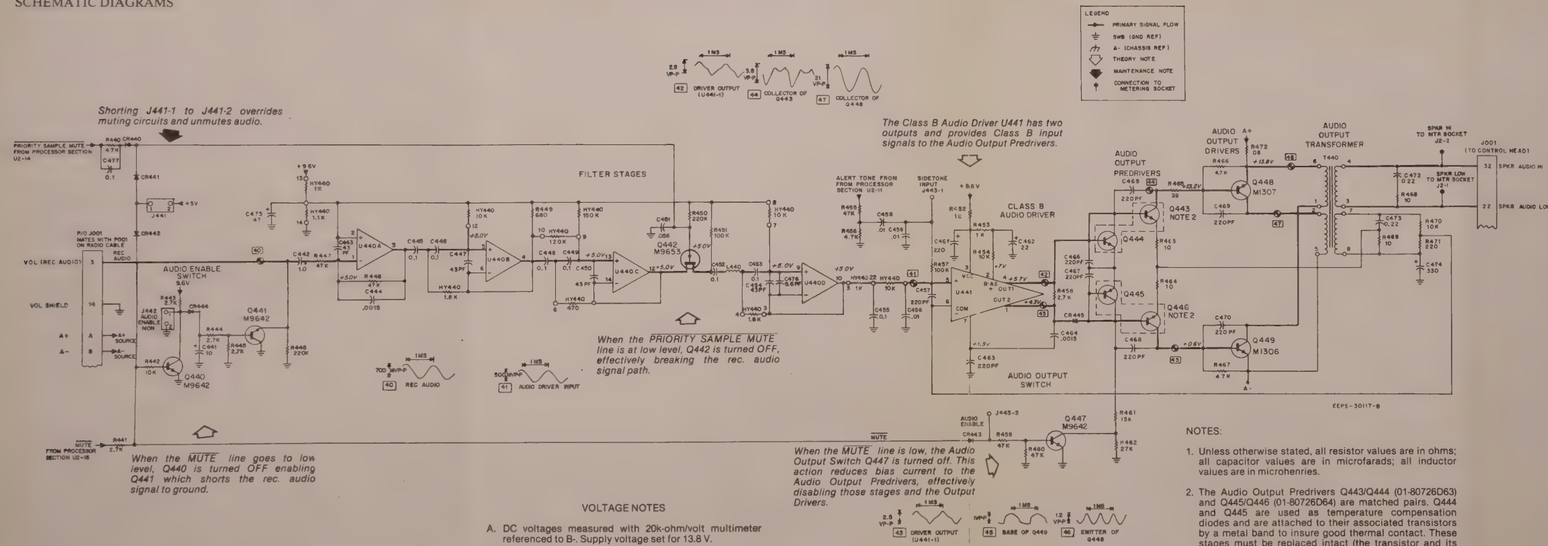
| Ref Number | Type | Description | Vcc (+ 5 V) | Gnd (Case Gr) |
|---|---|---|---|---|
| U1 | D74 | Opto-isolator | | |
| U2 | M8473 | 8-bit Addressable Latch | 16 | 8 |
| U3 | M8475 | 8-Channel Data Selector | 16 | 8 |
| U4, U6 | M8474 | Hex Buffer (Tri-State) | 16 | 8 |
| U5, U7 | M8177 | Hex Buffer (Tri-State) | 16 | 8 |
| U8 | M0136 | Microcomputer | 40 | 20 |
| U9 | M8453 | Dual Monostable Multivibrator | 16 | 8 |

*Microcomputer System, Receive Audio Section, and I/O Board Schematic Diagrams, Circuit Board Detail, and Parts Lists Motorola No. PEPS-32256-O (Sheet 1 of 3) 10-2-81-NPC*

# RECEIVE AUDIO SECTION AND I/O BOARD

SCHEMATIC DIAGRAMS

## RECEIVE AUDIO SECTION


LEGEND
PRIMARY SIGNAL FLOW
SW B+ (UNREGULATED B+)
A- (CHASSIS REF)
THEORY NOTE
MAINTENANCE NOTE
CONNECTION TO METERING SOCKET
Shorting J441-1 to J441-2 overrides muting circuits and unmutes audio.
The Class B Audio Driver U441 has two outputs and provides Class B input signals to the Audio Output Predrivers.
When the PRIORITY SAMPLE MUTE line is at low level, Q442 is turned OFF, effectively breaking the rec. audio signal path.
When the MUTE line goes to low level, Q440 is turned OFF enabling Q441 which shorts the rec. audio signal to ground.
When the MUTE line is low, the Audio Output Switch Q447 is turned off. This action reduces bias current to the Audio Output Predrivers, effectively disabling those stages and the Output Drivers.
PRIORITY SAMPLE MUTE FROM PROCESSOR SECTION U2-14
MUTE FROM PROCESSOR SECTION U2-18
VOL (REC AUDIO)
VOL SHIELD
AUDIO ENABLE SWITCH
FILTER STAGES
CLASS B AUDIO DRIVER
AUDIO OUTPUT PREDRIVERS
AUDIO OUTPUT DRIVERS
AUDIO OUTPUT TRANSFORMER
AUDIO OUTPUT SWITCH
ALERT TONE FROM PROCESSOR SECTION U2-11
SIDETONE INPUT J443-1
SPKR HI TO MTR SOCKET J2-2
SPKR LOW TO MTR SOCKET J2-1
J001 (TO CONTROL HEAD)
32 SPKR AUDIO HI
22 SPKR AUDIO LOW
DRIVER OUTPUT (U441-1)
COLLECTOR OF Q443
COLLECTOR OF Q448
REC AUDIO
AUDIO DRIVER INPUT
BASE OF Q449
EMITTER OF Q448
EEPS-30117-B

### VOLTAGE NOTES

A. DC voltages measured with 20k-ohm/volt multimeter referenced to B-. Supply voltage set for 13.8 V.

B. 21 indicates points at which ac voltages and waveforms are measured. Refer to circuit board detail.

C. Receive voltages are taken with 1 mV received carrier deviated 3 kHz with a 1 kHz audio tone and VOLUME control set for 11 V across J001-32 and J001-22.

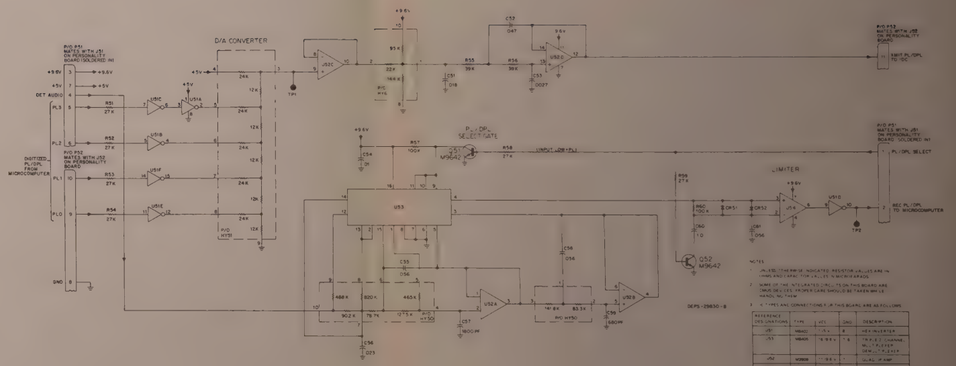
### NOTES:

1. Unless otherwise stated, all resistor values are in ohms; all capacitor values are in microfarads; all inductor values are in microhenries.

2. The Audio Output Predrivers Q443/Q444 (01-80726D63) and Q445/Q446 (01-80726D64) are matched pairs. Q444 and Q445 are used as temperature compensation diodes and are attached to their associated transistors by a metal band to insure good thermal contact. These stages must be replaced intact (the transistor and its associated diode) to insure proper operation.

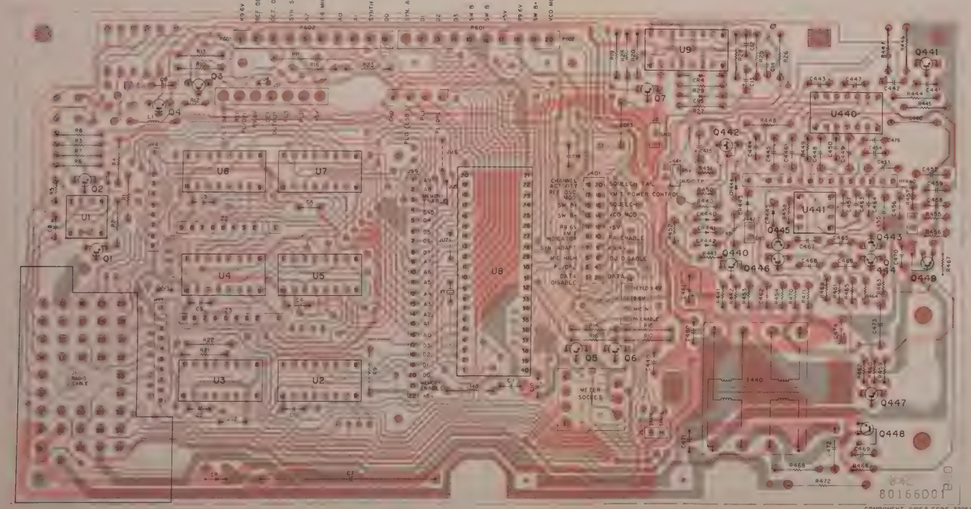
3. The processor section and the rec. audio output section of the Personality Board are shown on separate diagrams. All functional signals are shown on the appropriate diagram. The SW B+, SW B-, +9.6 V and +5 V input power connections are shown on the processor section diagram. The A+ and A- input power connections are shown on the rec. audio output section diagram.

## I/O BOARD




*Microcomputer System, Receive Audio Section, and I/O Board Schematic Diagrams, Circuit Board Detail, and Parts Lists*
*Motorola No. PEPS-32256-O*
*(Sheet 2 of 3)*
*10/2/81- NPC*

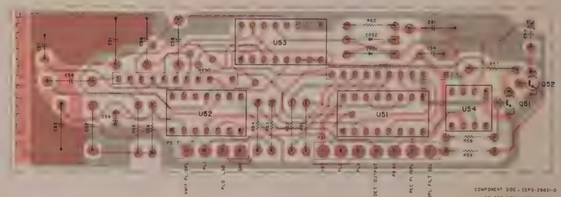
## HLN4257A PERSONALITY BOARD



SHOWN FROM SOLDER SIDE

COMPONENT SIDE* EEPS-32254-O
SOLDER SIDE = EEPS-32253-O
OL EEPS-32255-O

## I/O BOARD



SHOWN FROM SOLDER SIDE

COMPONENT SIDE = EEPS-29831-O
SOLDER SIDE = EEPS-29832-O
OL EEPS-29833-A

MAIN PLUG

| | |
|---|---|
| 1 | CONTROL HEAD STROBE |
| 2 | GATED DET. AUDIO |
| 3 | VOLUME (REC. AUDIO) |
| 4 | PTT |
| 5 | IGNITION/BATTERY |
| 6 | BUSY INDICATOR |
| 7 | SPARE |
| 8 | SW B+ |
| 9 | SW B+ |
| 10 | CHASSIS GROUND |
| 11 | MODE 12 (FUTURE) |
| 12 | MODE D |
| 13 | MODE F |
| 14 | SHIELD GROUND |
| 15 | SW B+ |
| 16 | MODE 8 |
| 17 | MODE 2 |
| 18 | SPARE |
| 19 | MODE 10 (FUTURE) |
| 20 | XMIT INDICATOR |
| 21 | SPARE |
| 22 | SPEAKER LO |
| 23 | MODE 7 |
| 24 | MODE 3 |
| 25 | MODE 4 |
| 26 | MODE 9 (FUTURE) |
| 27 | MIC HI |
| 28 | SQUELCH |
| 29 | MODE B |
| 30 | MODE 11 (FUTURE) |
| 31 | CHANNEL SCAN |
| 32 | PL/DPL DISABLE |
| 33 | SYSTEM 90/X |
| 34 | SPARE |
| 35 | SPARE |
| 36 | SPARE |
| 37 | SPEAKER H |
| A | A+ |
| B | A- |

## parts list

HLN4257 Audio Section of Personality Board — PL-7490-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **capacitor, fixed: ±5%, 100 V: unless otherwise stated** |
| C440 | 21-11015805 | 220 pF ±10% |
| C441 | 23-11013E57 | 10 ±20%, 20 V |
| C442 | 23-11013D01 | 1.0 ±20%, 20 V |
| C443 | 21-11014H40 | 43 pF |
| C444 | 8-81017A02 | .0015, 50 V |
| C445 446 | 8-84637L37 | 0.1 |
| C447 | 21-11014H40 | 43 pF |
| C448, 449 | 8-84637L37 | 0.1 |
| C450 | 21-11014H40 | 43 pF |
| C451 | 8-81017B15 | .056 ± 10, 50 V |
| C452 453 | 8-84637L37 | 0.1 |
| C454 | 1-11014H40 | 43 pF |
| C455 | 8-84637L37 | 0.1 |
| C456 | 8-81017A02 | .01, 50 V |
| C457 | 21-11015805 | 220 pF ±10% |
| C458, 459 | 21-11015C07 | .01 +80, 20% |
| C460 | 21-11015805 | 220 pF ±10%, 100 V |
| C461 | 23-82747L06 | 220 ±10%, 25 V |
| C462 | 23-11013C56 | 22 ±20%, 15 V |
| C463 | 21-11015805 | 220 pF ±10% |
| C464 | 8-81017A02 | .0015, 50 V |
| C465 thru 471 | 21-11015805 | 220 pF ±10% |
| C472 473 | 8-84637L22 | 0.22 ±10% |
| C474 | 23-82747L01 | 330 +100-10%, 20 V |
| C475 | 23-84538D05 | 47 ±20%, 25 V |
| C476 | 21-11014H19 | 5.6 pF |
| C477 | 8-84637L37 | 0.1 |
| CR440 thru 445 | 48-83654H01 | **diode: (see note 1)** silicon |
| HY440 | 51-82142K07 | **hybrid:** resistor network |
| L440 | 24-83961B07 | **coil, rf:** choke, ferrite |
| Q440, 441 | 48-869642 | **transistor: (see note 1)** NPN, type M9642 |
| Q442 | 48-869652 | N-channel FET, type M9653 |
| Q443 thru 446 | | (see note 2) |
| Q447 | 48-849642 | NPN, type M9642 |
| Q448 | 48-84413L07 | PNP, type M1307 |
| Q449 | 48-84413L06 | NPN, type M1306 |
| R440 | 6-11009E65 | **resistor, fixed: ±5%; 1/4 W:** unless otherwise stated 4.7k |
| R441 | 6-11009E59 | 2.7k |
| R442 | 6-11009E73 | 10k |
| R443, 444 | 6-11009E59 | 2.7k |
| R445 | 6-11009A59 | 2.7k |
| R446 | 6-11009E06 | 220Ω |
| R447, 448 | 6-11009A89 | 47k |
| R449 | 6-11009E45 | 680 |
| R450 | 6-11009F06 | 220k |
| R451 | 6-11009E07 | 100k |
| R452 | 6-11009E01 | 10 |
| R453 | 6-11009E49 | 1k |
| R454 | 6-11009E73 | 10k |
| R455 | 6-11009F | 47k |
| R456 | 6-11009E65 | 4.7k |
| R457 | 6-11009E87 | 100k |
| R458 | 6-11009E59 | 2.7k |
| R459, 460 | 6-11009E89 | 47k |
| R461 | 6-11009E77 | 15k |
| R462 | 6-11009E83 | 27k |
| R463, 464 | 6-11009E01 | 10 |
| R465 | 6-11009E15 | 39 |
| R466, 467 | 6-11009E65 | 4.7k |
| R468 | 6-11009A01 | 10 |
| R469 | 6-11009E01 | 10 |
| R470 | 6-11009E73 | 10k |
| R471 | 6-11009E33 | 220 |
| R472 | 17-82350A14 | 98 +10%, 1 W |
| T440 | 25-84083B04 | **transformer, audio:** pri no. 1 and 2 dc resist = 5 ohms sec no. 1 windings 4 and 3 dc resist = 1 ohm sec no. 2 (windings 7 and 8) dc resist = 2 ohms |
| U440 | 51-83629M06 | **integrated circuit: (see note 1)** quad op-amp, type M2906 |
| U441 | 51-83629M02 | op amp, type M2902 |

For parts not included in the above parts list refer to the mechanical part section

HLN4257A Personality Board (Microcomputer Section) — PL 7491-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **capacitor, fixed: uF unless otherwise stated** |
| C1 thru 6 | 21-11015A07 | .01 +80-20% |
| C7 | 23-83210A08 | 100 +150-10% 25 V |
| C8 | 23-84538G01 | 1.0 +100-10% 35 V |
| C9 10 | 23-84538G10 | 10 +200% 20 V |
| C11 | 21-11015805 | 220 pF +10%-100 V |
| C12 13 | 23-84538G01 | 1.0 +100% 35 V |
| C14 | 8-11017A14 | .047 +5%, 50 V |
| C15 | 21-11015B25 | 220 pF +10%-100 V |
| CR1 | 48-82125G02 | **diode, (see note)** silicon |
| CR3 | 48-84616A01 | hot carrier |
| CR4 5 | 48-83654H01 | silicon |
| HY1 thru 4 | 51-82142K10 | **hybrid:** resistor network |
| J1 | 1-80708T31 | **connector, receptacle** assembly, front connector, and feed-thru plate |
| J2 | 9-84207B01 | female, 7 contact |
| J3 | 28-84318M08 | male, 2 contact |
| J4 | 28-84318M08 | male, 4 contact |
| J5 | 28-84318M08 | male, 2 contact |
| J99 | 28-52620J03 | male, 22 contact (for memory module) |
| J401 | 28-83603M01 | male, 20 contact |
| L1, 2 | 24-83961B02 | **coil, rf:** ferrite bead |
| P601, 602 | 28-82647K02 | **connector, plug:** male, 10 contact |
| Q1 | 48-869642 | **transistor: (see note)** NPN, type M9642 |
| Q3 4 | 48-869328 | PNP, type M9328 |
| Q5 6 7 | 48-869642 | NPN, type M9642 |
| R1 2 | 6-11009A73 | **resistor, fixed:** 10k |
| R3 4 | 6-11009A83 | 27k |
| R5 | 6-11009A13 | 1.5k |
| R7 | 6-11009A73 | 10k |
| R10 | 6-11009A89 | 47k |
| R11 | 6-11009A73 | 10k |
| R12 | 6-11009E89 | 47k |
| R13 | 6-11009A43 | 560 |
| R14 | 6-11009A89 | 47k |
| R15,16 | 6-11009A97 | 100k |
| R17 | 6-11009A89 | 47k |
| R18 | 6-11009A61 | 3.3k |
| R19 | 6-11009A83 | 27k |
| R20, 21 | 6-11009A73 | 10k |
| R22 | 6-11009A89 | 47k |
| R23 24 | 6-11009A73 | 10k |
| R25 | 6-11009A85 | 33k |
| R26 | 6-11009A89 | 47k |
| R27 | 6-11009A53 | 1.5k |
| R28 | 6-11009A97 | 100k |
| R29 | 6-11009A85 | 33k |
| U1 | 51-84621K4B | **integrated circuit: (see note)** dual opto isolator, type M2146 |
| U2 | 51-82884L73 | multiplex output/data latch, type M8473 |
| U3 | 51-82884L75 | input multiplexer, type M8475 |
| U4 | 51-82884L74 | hex non-inverting driver, type M8474 |
| U5 | 51-84561L77 | hex non-inverting driver, type M8177 |
| U6 | 51-82884L74 | hex non-inverting driver, type M8474 |
| U7 | 51-84561L77 | hex non-inverting driver, type M8177 |
| U8 | 51-82907K56 | microcomputer |
| U9 | 51-82884L53 | dual monostable |
| Y1 | 48-82611M10 | **crystal: (see note)** 2.500 MHz |
| | | **mechanical parts** |
| | 4-84345A12 | WASHER, insulator |
| | 14-84602K01 | INSULATOR, stat |
| | 9-83893M01 | SOCKET, IC |
| | 42-83492M01 | CLIP |

notes:
1 For optimum performance, diodes, transistors, and integrated circuits must be ordered by Motorola part numbers.
2 Transistors Q443/Q444 (01-80707R063) and Q445/Q446 (01-80726D64) are matched and must be replaced as an assembly.

TRN8876A Input/Output Board — PL-8970-A

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **capacitor, fixed: uF ± 5%; 250 V unless otherwise stated** |
| C51 | 8-84637L28 | .01 +80-20% |
| C52 | 8-84637L12 | .047 +10% |
| C53 | 8-84637L50 | .0027 ± 10% 1000 V |
| C54 | 21-11015A07 | .01 +80-20% 100 V |
| C55 | 8-84637L49 | .056 |
| C56 | 8-84637L09 | .022 400 V |
| C57 | 21-84393M02 | 1800 pF, 50 V |
| C58 | 8-84637L49 | .056 |
| C59 | 21-84393M01 | 680 pF, 50 V |
| C60 | 23-11013D01 | 1.0 ±10%, 25 V |
| C61 | 8-84637L49 | .056 |
| CR51, 52 | 48-83654H01 | **diode: (see note)** silicon |
| HY50 | 51-82142K08 | **hybrid, assembly:** resistor network |
| HY51 | 51-82142K11 | resistor network |
| P51 | | **connector, plug:** consists of: |
| | 28-84797F09 | male, 7 contact (right angle) |
| | 28-84797F08 | male, 4 contact (right angle) |
| Q51, 52 | 48-869642 | **transistor: (see note)** NPN, type M9642 |
| R51 thru 54 | 6-11009A83 | **resistor, fixed: ± 5%; 1/4 W: unless otherwise stated** 27k |
| R55, 56 | 6-11009A87 | 39k |
| R57 | 6-11009A97 | 100k |
| R58, 59 | 6-11009A83 | 27k |
| R60 | 6-11009A97 | 100k |
| U51 | 51-82884L02 | **integrated circuit: (see note)** hex inverter, type M8402 |
| U52 | 51-83629M06 | quad op amp, type M2906 |
| U53 | 51-82884L05 | triple 2-channel analog multiplexer/ demultiplexer, type M8405 |
| U54 | 51-83629M07 | bi polar op amp, type M2907 |

**note**
The mechanical parts are listed in the mechanical parts list presented in the general maintenance section of this manual.

note: For optimum performance, diodes, transistors, and integrated circuits must be ordered by Motorola part numbers.

*Microcomputer System, Receive Audio Section, and I/O Board Schematic Diagrams, Circuit Board Detail, and Parts Lists Motorola No. PEPS-32256-O (Sheet 3 of 3)*
*10-2-81- NPC*

## 1. GENERAL

The *SYNTOR X* frequency synthesizer is used to directly generate the first receive injection frequency and transmitter carrier. In the receive mode, the synthesizer locks on a frequency that is 53.9 MHz (first i-f) higher than the desired receive frequency. In the transmit mode, the synthesizer locks on the transmit output frequency. The synthesizer employs a phase-locked-loop (PLL) that operates at the desired output frequency and consists of: a 14.4 MHz reference oscillator, separate transmit and receive low-noise voltage-controlled oscillators (VCO), a high-speed programmable divide-by-3-or-4 variable modulus prescaler, a low-speed programmable divider, a sample-and-hold phase detector, and a loop adaptive filter. The 14.4 MHz reference oscillator output is applied, via an injection tripler, to the second mixer of the receiver, where it serves as the low-side second injection frequency. The synthesizer circuits are located on the common circuits board, rf board, and in the rf internal casting.

## 2. THEORY OF OPERATION

### 2.1 INTRODUCTION

2.1.1 The PLL (phase-locked-loop) synthesizer is a single negative-feedback-loop that uses the phase of the input signals to the phase detector as the controlling variable. The output of a high-accuracy, temperature-compensated crystal reference oscillator (U608) is divided down in frequency by the reference divider (part of U602). The reference divider provides a high-stability 5.00 kHz (6.25 kHz for some customer frequencies) square-wave output that is routed from the reference divider to the phase detector (U603-2) to serve as the reference frequency input.

2.1.2 The PLL negative feedback input, which originates at the VCO, is applied to the loop frequency input of the phase detector (U603-23). The VCO provides an output frequency proportional to the voltage on its steering line (P650-2). The VCO consists of a transmit FET rf oscillator (Q1403), which operates in a frequency range from 150-174 MHz, and a receive FET rf oscillator (Q1401) which operates in a frequency range from 203.9-227.9 MHz. The VCO output frequency is divided down by a programmable N divider, which provides a loop frequency output equal to the VCO output frequency divided by N, i.e.:

$$f_{(loop)} = f_{(vco)}/N$$

where: $f_{(loop)}$ = N divider loop frequency output
$f_{(vco)}$ = VCO output frequency
N = integer

2.1.3 The loop frequency and the reference frequency are applied to the phase detector (U603-23, and U603-2, respectively), whose function is to provide a dc output voltage proportional to the phase difference between the two frequencies (i.e., the loop and reference frequencies). Phase is used as the controlling variable, since small phase errors may exist in the locked loop but frequency errors cannot occur. The phase detector dc output voltage (PHASE DET OUT at U603-15) is applied, via the loop adaptive filter, to the VCO steering line, thus completing the feedback loop. The loop filter controls the PLL closed loop response and removes noise from the phase detector output. The loop negative feedback action is as follows. If the VCO output frequency goes high, the N divider loop frequency output also goes high, thus causing a leading phase displacement at the phase detector loop input. Since the reference signal phase does not change, the phase detector internal circuits detect this condition and cause the generation of a lower dc voltage at the output U603-15. This signal is applied to the VCO steering line, via the loop adaptive filter, causing a reduction in frequency, thus compensating for the original frequency difference.

### 2.2 LOOP PROGRAMMING AND CONTROL

2.2.1 For frequency generation and control, the microcomputer reads the programming information from the personality board memory module, combines it with the synthesizer control information, and multiplexes this information to the programmable

divider (U602). The programming information, contained in six 4-bit words, is applied to the multiplex programmed divider via four data lines (D0, D1, D2, D3) and via three data word address lines (A0, A1, A2). Address lines A0, A1, and A2 are used in the multiplexing sequence to tell the divider which of the six 4-bit words is being sent by the microcomputer on the data lines.

2.2.2 The bits sent to the divider are used in the following manner: One of the bits is used to select between transmit or receive VCO operation. This bit is transferred from the divider (U602-19) to the transmit-receive VCO switching network which provides regulated 8.4 V to the transmit or receive VCO via P650-3 and P650-1, respectively. One bit is also used to determine the frequency range of the VCOs. This bit is transferred from the divider (U602-20) to the bandshift network, which provides the proper bandshift information to the VCOs, via P650-5 and P650-6. Sixteen bits are used to program the "A" and "B" counters, which are internal to the programmable divider. Two bits are used to program a reference divider. Two latched bits ($\overline{C0}$ and $\overline{C1}$) are sent from the multiplex programmed divider to the programmable variable-modulus prescaler (U602-15 and U602-16, respectively) to control its operation during the divide cycle. Two other latched outputs from the divider, $\overline{S0}$ and $\overline{S1}$, are used by the sample-and-hold phase detector to control the loop adaptive filter. When set high, $\overline{S1}$ indicates a change in frequency. In this case, a seventh word is generated to clear the frequency change indication by setting $\overline{S1}$ low, thus generating a control pulse. $\overline{S0}$ is used to switch between the transmit and receive loop filters (high for transmit filter).

2.2.3 The six 4-bit words on the data lines remain the same once the condition of synthesizer operation and the frequency have been selected. Any change in radio mode causes different memory locations in the memory module to be addressed by the microcomputer. Consequently, the six 4-bit words may supply different information to the divider, via the data lines. The microcomputer will notify the divider, via the STROBE line, when the binary information on the data and address lines can be read into the divider and latched in without any chance of error.

## 2.3 DIVIDER

2.3.1 The programmable N divider uses a method of frequency division known as a "dual-modulus prescaling". Two dual-modulus prescalers are used: a divide-by-3-or-4 prescaler (with its own internal programmable "C" counter) and a divide-by-63-or-64 prescaler. The divide-by-63-or-64 prescaler, with its two programmable counters "A" and "B", is internal to divider U602. The output frequency of each of the two prescalers is, first, divided by one divisor to provide a fixed number of counts and, then, by a second divisor to provide a different number of counts. The total division performed by this system may be set to an integral value N by programming counters "A", "B", and "C". This system of divison allows the basic division capabilities of programmable divider U602 to be expanded to a higher operating frequency without losing resolution.

2.3.2 Each PLL output frequency requires that a different value of N be programmed into the programmable counters. On the positive-going loop pulse edge, the divide-by-3-or-4 prescaler starts dividing by four and continues to do so until the "C" counter reaches zero. At this time, the prescaler enters into the divide-by-3 mode. Once the loop pulse goes low, the "C" counter is preset to the value determined by the $\overline{C0}$ and $\overline{C1}$ bits. This causes a new cycle to begin on the positive-going edge of the next loop pulse.

2.3.3 The divide-by-63-or-64 variable-modulus prescaler works in a similar fashion. When a loop count begins, it initially divides by 64 for the number of times programmed into the "A" counter. When the "A" counter counts to zero, the loop pulse goes low and the prescaler changes to the divide-by-63 mode. It stays in this mode until the "B" counter reaches zero. At this time the loop pulse goes high and the cycle repeats.

2.3.4 The 14.4 MHz reference oscillator input frequency at U602-2 is acted upon by another programmable divider to provide one of three reference frequencies: 5 kHz or 6.25 kHz. One word of the frequency select data contains two bits (D0 and D1) which select one of three reference frequencies, as shown in Table 1.

*Table 1.*
*Reference Frequency Selection*

| $D_0$ | $D_1$ | Reference Frequency |
|---|---|---|
| 0 | 0 | unused |
| 1 | 0 | 6.25 kHz |
| 1 | 1 | 5.00 kHz |

2.3.5 The frequency select data also contains bits VCO1 and VCO2. Bit VCO2 is used to select the VCO band shift window required by the selected operating frequency. (Refer to the VCO paragraph for details on the band shift windows.) When the VCO bit is latched into the divider, VCO2 is forwarded from U602-20 as a BAND SHIFT signal to the bandshift switching network. It is then routed via the feed-through plate to the VCO. An NPN transistor on U600 compensates for the differing modulation characteristics of the VCO windows. When the BAND SHIFT signal is high (at U602-20), the transistor turns on, providing a lower-amplitude audio signal to the VCO. (The VCO requires less audio input to fully modulate the rf signal when U602-20 is high than when it is low.)

## 2.4 PHASE DETECTOR

2.4.1 Phase detector U603 compares the reference and loop frequency outputs of the divider circuit and uses this information to generate a dc output signal that controls the VCO frequency. The phase detector also

monitors the FREQUENCY CHANGE line ($\overline{S1}$) and the LOW BANDWIDTH SELECT line ($\overline{S0}$) and uses this information to generate control signals for the adaptive filter.

2.4.2 The phase detector output signal level is controlled by the length of time between the positive transition of the reference signal and the positive transition of the loop signal. When the reference signal goes high (at U603-2), ramp generator Q603 turns on, maintaining a constant current through C630. This constant current generates a linear rise (ramp) in the voltage at U603-24. The rise of the ramp voltage halts when the LOOP signal (at U603-23) switches to a high level, causing Q603 to turn off.

2.4.3 The positive transition of the loop signal, in addition to halting the ramp generator, resets an internal sample timing circuit. The ramp voltage is held constant for a period of time determined by sample timing capacitor C631. During this time, the two hold capacitors (C632 and C633) are charged to a level determined by the ramp voltage. At the end of the sample time, the ramp capacitor is discharged in preparation for the next cycle.

2.4.4 The accumulated charge on the hold capacitors is used to control the conduction of a push-pull output driver. The output driver consists of an internal NPN transistor and an external PNP transistor controlled by the signal at U603-17. The PHASE DETECTOR OUTPUT signal at U603-15 is coupled, via the adaptive filter, to the VCO, where it controls the generation of injection frequencies.

2.4.5 In addition, the phase detector generates control signals for the adaptive filter. The FREQUENCY CHANGE signal at U603-5 and the LOW BANDWIDTH SELECT signal at U603-3 are decoded by the phase detector to provide four control signals that are coupled to the adaptive filter. These four control signals are: ADAPT, $\overline{\text{ADAPT}}$, RSW, and TSW (appearing at U603-10, -7, -9, and -8, respectively).

2.4.6 When changing operating channels while in the receive mode or changing from the transmit mode to the receive mode, the FREQUENCY CHANGE pulse at U603-5 causes the ADAPT line to go high and the $\overline{\text{ADAPT}}$ line to go low. Since the LOW BANDWIDTH SELECT line is low, the RSW line is driven high, the TSW is driven low, and the adaptive filter is forced into the receive-adapt mode. The $\overline{\text{ADAPT}}$ line returns to a high level and the ADAPT line returns to a low level after approximately 3.0 milliseconds, under the phase detector control, forcing the adaptive filter to enter into the normal receive mode.

2.4.7 When the PTT pushbutton is pressed, the FREQUENCY CHANGE pulse causes the ADAPT line to go high and the $\overline{\text{ADAPT}}$ line to go low. Since the LOW BANDWIDTH SELECT line is high, the TSW line is driven high, the RSW is driven low, and the adaptive filter is forced into the transmit-adapt mode. The ADAPT and $\overline{\text{ADAPT}}$ lines will switch states after approximately 15 milliseconds, under control of the phase detector, and the adaptive filter is forced to enter into the normal transmit mode.

2.4.8 While the ADAPT line is high during the transmit-adapt mode, the power amplifier will be disabled. (This line is connected to the personality board via J602-11.) Moreover, the ADAPT line is forced to switch to a high state when the synthesizer cannot achieve lock, thus preventing the radio from transmitting unstable or off-frequency signals.

2.4.9 To achieve maximum switching speed, the microcomputer provides new data to the synthesizer at the appropriate time of the divide cycle. The phase detector forwards a SYNTHESIZER SYNC signal, from U603-4 via J602-9, notifying the microcomputer of the appropriate time to send new frequency programming information.

## 2.5 ADAPTIVE FILTER

### 2.5.1 General

2.5.1.1 The adaptive filter is a low-pass filter in the steering line between the phase detector and the VCO. This filter removes noise and variations in the steering line level to prevent unwanted modulation of the VCO.

2.5.1.2 The adaptive filter, which is connected to the PHASE DETECTOR OUTPUT line U603-15, is controlled by the phase detector to operate in one of four selectable modes, depending upon the state of the synthesizer at a given time. Transmit adapt mode and receive adapt mode differ only in the amount of time spent in adapt condition, while the transmit mode and receive mode each requires different filter characteristics. These characteristics are selected by transmission gates which switch the filter components into and out of the steering line signal path, as required.

### 2.5.2 Filter Mode Selection

2.5.2.1 The adaptive filter operates in one of four selectable modes: transmit, receive, transmit-adapt, and receive-adapt. Each mode is selected by a unique combination of states present on two complementary pairs of lines: the TSW and RSW lines make up one such pair, and the ADAPT and $\overline{\text{ADAPT}}$ lines make up the other. These lines are coupled from the phase detector to the adaptive filter and are connected to the input pins of mode select gates (U604 A&B). The ADAPT line is also connected to transmission gates U605 and U606.

2.5.2.2 The low-input AND gates (U604 A&B) provide two output lines: TRANSMIT MODE SELECT and RECEIVE MODE SELECT, respectively.

For each filter operation mode selected, one of these output lines is switched into a high state (between +8.6 and +9.6 V). Since these gates employ low-level inputs, the output of a gate will go high whenever both of its inputs go low. Or, expressed as a Boolean expression, the input/output signals of, say, U604A will be:

$$\text{TRANSMIT MODE SELECT} = \overline{\text{ADAPT}} \bullet \overline{\text{RSW}}$$

2.5.2.3 In conjunction with the ADAPT line, the output lines of the mode select gates (U604 A&B) control transmission gates U605 and U606. When a selector output is forced into a high level, the associated transmission gates turn on, passing the signals, as a closed switch. Transmission gates U605A-D have ON impedances of less than 200 ohms, and gates U606A-D have ON impedances of less than 500 ohms.

2.5.3 Transmit Mode

2.5.3.1 When the synthesizer is in the normal transmit mode, the phase detector drives the TSW and $\overline{\text{ADAPT}}$ lines high and their complements, RSW and ADAPT, low. The output of gate U604A goes high, causing transmission gates U605A, U606A, and U606D to turn on. The natural loop frequency of the synthesizer in this mode is approximately 15 Hz. The adaptive filter stays in this mode as long as the radio is transmitting.

2.5.3.2 In this mode, the steering line is filtered by R652 and a shunt path to ground consisting of C649, C641, C634, and R653. (The ON impedance of the transmission gates is neglected.) This signal passes to the VCO via a test jumper (JU600) and J650-2.

2.5.4 Receive Mode

2.5.4.1 When the synthesizer is in the receive mode, the phase detector drives the RSW and $\overline{\text{ADAPT}}$ lines high and their complements, TSW and ADAPT, low. The output of gate U604B goes high, causing transmission gates U605C and U606C to turn on. The natural loop frequency of the synthesizer in this mode is approximately 75 Hz. The adaptive filter remains in this mode while the radio is in the receive mode.

2.5.4.2 In this mode, the steering line is filtered by R635, a shunt path consisting of R636, C640, and C641, and by R637 and C654. (The ON impedance of the transmission gates is neglected.) The signal passes through the test jumper to the VCO via J650-2.

2.5.5 Transmit-Adapt Mode

2.5.5.1 When the synthesizer is in the transmit-adapt mode, the TSW and ADAPT lines are driven high by the phase detector and their respective complements, RSW and $\overline{\text{ADAPT}}$, are driven low. Transmission gates U605B, U605D, U606D are directly turned on by the ADAPT line. The synthesizer has a high natural loop frequency in this mode, allowing it to change frequencies rapidly. The adaptive filter is switched into this mode for approximately 15 milliseconds while the radio changes from the receive mode to the transmit mode. The transmitter is inhibited in this mode by the SYNTHESIZER ADAPT line.

2.5.5.2 In this mode, transmission gate U606B bypasses the greater part of the adaptive filter. A grounded capacitor, C641, is connected to the steering line (the ON impedance of the transmission gates is neglected). While the filter is in this mode, C641 and C654 are being charged. The charge on C654 prevents the VCO from changing frequency during the transition from the transmit-adapt mode to the transmit mode. C654 always remains connected to the steering line. The steering line passes to the VCO through the test jumper via J650-2.

2.5.6 Receive-Adapt Mode

2.5.6.1 When the synthesizer is in the receive-adapt mode, the RSW and ADAPT lines are driven high by the phase detector and their respective complements, TSW and $\overline{\text{ADAPT}}$, are driven low. Transmission gates U605B, U605D, and U606B are directly turned on by the ADAPT line. The synthesizer has a high natural loop frequency in this mode, allowing it to change injection frequencies rapidly. The adaptive filter switches into this mode for approximately 3.0 milliseconds while the radio changes from the transmit mode to the receive mode or from one receive frequency to another (such as when changing the operating channel of the radio).

2.5.6.2 In this mode, the greater part of the adaptive filter is shorted by transmission gate U606B, and the steering line is connected to C641. (The ON impedance of the transmission gates is neglected.) When the filter is in the receive-adapt mode, C641 and C654 are being charged. The accumulated charge on C654 prevents the VCO from changing frequencies during the transition from the receive-adapt mode to the receive mode. C654 always remains connected to the steering line. The steering line passes to the VCO through the test jumper and J650-2.

2.5.6.3 When the frequency is changed (or if, for any reason, the loop falls out-of-lock), the phase detector will cause the adaptive filter to switch to the ADAPT mode. Consequently, the $\overline{\text{ADAPT}}$ line switches to a low state, causing the OUT-OF-LOCK indicator LED to turn on. Therefore, in normal operation of the frequency synthesizer, the OUT-OF-LOCK indicator LED turns on for a brief period whenever the frequency is being changed. During *Channel Scan* operation, the radio can be continuously changing frequencies, at a fast rate, causing the OUT-OF-LOCK indicator LED to give a dim indication. However, a strongly lit indicator LED points to the presence of an out-of-lock fault in the frequency synthesizer. Thus, this indicator LED is useful for troubleshooting purposes.

2.5.6.4 Various radio functions are deactivated each time the frequency synthesizer goes into the ADAPT mode. First, the high ADAPT output disables the radio audio stages via the squelch circuits on the common circuits board. In addition, the transmitter and IDC circuits will also be disabled via the personality board. This fail-safe feature will prevent transmitter key-up (in the unlikely event that a loss-of-lock malfunction occurs), thus preventing the generation and transmission of uncontrolled rf signals.

2.5.7 Super Filter

2.5.7.1 Because the VCO requires a very pure dc supply voltage, an ultra-low-pass filter (U600) is used to provide the VCO with very-low-noise +8.6 output voltage. Any ripple or noise present on the +9.6 V supply line is removed by the filter, thus preventing the unwanted modulation of the VCO. A 1 volt drop occurs across the filter, thus lowering the output voltage from +9.6 to +8.6 V.

2.5.7.2 The super filter consists of a low-pass filter, an error amplifier, and an external series-pass transistor (Q601). The +9.6 V supply is connected to U600-1 as well as to the emitter of Q601. Internally, the input from U600-1 passes through a low-pass filter to the non-inverting input of the error amplifier. C603, connected to U600-2, forms part of the low-pass filter. The output line (also connected to the collector of Q601) is fed back to the inverting input of the error amplifier through U600-4. The error amplifier output is connected to the base of Q601 via U600-3 and is used to control the conduction of the transistor. These connections enable the super filter to compare the output line voltage with the filtered input line voltage and to increase or decrease the conduction of Q601 to remove any ripple or noise present on the VCO supply line. The VCO supply if further filtered by C604, which is connected to ground. This filtered supply is then forwarded to the transmit-receive VCO switching network. Depending on the state of U602-19, transmit 8.4 V or receive 8.4 V is sent to the respective VCO through the VCO interconnect plate, via J650-3 and J650-1. The filtered 8.6 V supply is also forwarded to the bandshift switching network, which selects the proper state of the Bandshift 1 and Bandshift 2 lines, depending on the state of U602-20.

2.5.8 Feedback Buffer

2.5.8.1 A signal at the oscillator frequency is fed back from the transmit and receive buffers to the main board. This signal is used by the divider/phase detector circuits to monitor the oscillator frequency.

2.5.8.2 The feedback buffer, Q602, accepts an input from two capacitors forming a capacitive tap network from the transmit buffer and receive buffer inputs. This input signal is forwarded via a coaxial cable and connector P/J600. The feedback amplifier output is coupled to divide-by-3-or-4 prescaler (U601) via C607.

## 2.6 VOLTAGE-CONTROLLED OSCILLATOR (VCO)

### 2.6.1 General

2.6.1.1 The HLD4103A VCO contains separate transmit and receive voltage-controlled circuits. The outputs of each VCO are routed to separate buffer amplifiers on the HLN1053A Buffer Module. The VCO and the buffer amplifier provide frequency-modulated transmit injection frequencies and receive injection frequencies. Both kits are constructed on alumina thick-film substrates.

2.6.1.2 The VCO operating frequency range extends from 150 MHz to 174 MHz (transmit VCO) and from 203.9 MHz to 227.9 MHz (receive VCO). Use of PIN diode switches allows each 24 MHz bandwidth to be covered in two ranges. The VCO and buffer also provide a feedback signal whose frequency is the same as the injection frequency for use by the phase-locked loop synthesizer.

### 2.6.2 Receive Oscillator Circuit

2.6.2.1 The receive oscillator employs a grounded-gate Colpitts oscillator that uses a FET (Q1401) as the amplifying element. This oscillator operates 53.9 MHz above the desired receive frequency. By employing a PIN-diode bandshift switch along with varactor tuning diodes, the full 24 MHz bandwidth can be tuned in two ranges, using a single oscillator. A transmission line section is PIN-switched in parallel with part of the main resonator transmission line to raise the bandshift resonant frequency. The drain of Q1401 is coupled to the main resonator transmission line through C1405.

2.6.2.2 The transmission line is equipped with microstrip capacitors that act as trimming capacitors for the oscillator tank circuit. These capacitors, which are adjusted at the factory, are not dependent on the customer's frequencies.

2.6.2.3 The oscillator provides an output signal that is coupled to amplifier Q1402, which is located on the VCO substrate. Q1402, in turn, provides an output signal that is fed to the receive buffer amplifier (Q1460 and Q1461) which is located on an alumina substrate in a compartment adjacent to the VCO. The receive buffer amplifier provides two output signals: (1) a signal at the receive injection frequency that is coupled, via P600, to the rf board to drive the prescaler to provide feedback to the PLL synthesizer; and (2) a second signal that is fed to the receive injection filter.

2.6.2.4 Supply voltage for the receive oscillator and buffer amplifier is present only during the receive condition. REC 8.4 V is routed to buffers Q1460 and Q1461 through the center conductor of the receive VCO output coaxial cable.

2.6.3 Transmit Oscillator Circuit

2.6.3.1 The transmit oscillator employs a grounded-gate Colpitts oscillator that uses a FET (Q1403) as the amplifying element. This oscillator operates at the desired transmit frequency (150 to 174 MHz). Full 24 MHz transmit bandwidth is achieved by using varactor tuning diodes and a second PIN-diode Bandshift switch; this allows the transmit oscillator to shift between two frequency ranges. The transmission line, which provides the frequency shift in the Bandshift state, is shared by the transmit and receive oscillators. Polarity of the two PIN-diodes is such that when the Bandshift 1 line goes high (and the Bandshift 2 line goes low), CR1407 turns on, causing the Bandshift transmission line to switch in parallel with part of the main resonator line. The effects of the receive main transmission line are negligible because of the high OFF impedance of CR1406. When the Bandshift 1 line goes low (and Bandshift 2 goes high), CR1407 turns off and CR1406 turns on, switching the transmit oscillator into the lower frequency range. This state of the Bandshift 1 and Bandshift 2 lines (for the transmit oscillator lower frequency range) is also used for the receive oscillator Bandshift range.

2.6.3.2 The main transmission line of the transmit oscillator is equipped with microstrip capacitors that act as trimming capacitors for the oscillator tank circuit. These capacitors, which are adjusted at the factory, do not depend on the customer's frequencies.

2.6.3.3 The oscillator provides an output that is coupled to amplifier Q1404, which is located on the VCO substrate. Q1404, in turn, provides an output signal that is routed to the transmit buffer amplifier (Q1450 and Q1451); this amplifier is located on an alumina substrate in a compartment adjacent to the VCO. The transmit buffer amplifier provides two output signals: (1) a signal at the transmit frequency that is coupled, via P600, to the rf board to drive the prescaler to provide feedback to the PLL synthesizer; and (2) a second signal that is coupled to the IPA (intermediate power amplifier) via P700.

2.6.3.4 Supply voltage for the transmit oscillator and buffer amplifier stages is present only during the transmit state. TX +8.4 V is coupled to the buffers (Q1450 and Q1451) through the center conductor of the transmit VCO output coaxial cable.

2.6.4 Steering Line Circuit

2.6.4.1 The STEERING line, in conjunction with the Bandshift lines, determines the operating frequency of the VCO. The STEERING line is driven by the phase detector (U603) and is coupled to the transmit and receive VCOs, via the adaptive filter. The phase detector provides a dc output voltage to maintain the transmit VCO output at the desired frequency during transmit condition; it also maintains the receive VCO output at the desired frequency during receive condition. When the frequency is changed, the phase detector dc output voltage shifts to change the oscillator frequency and then maintain this new frequency. The graph of Figure 1 shows the transmit and receive oscillator frequencies as a function of the STEERING line dc voltage.

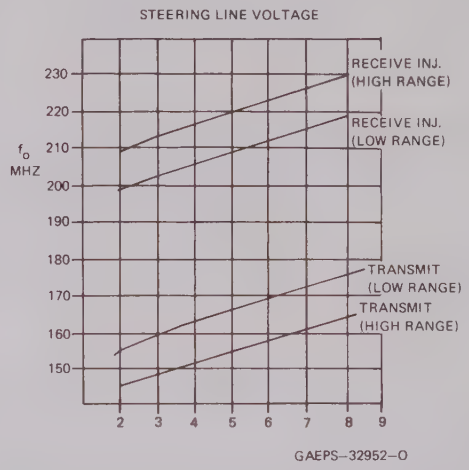



*Figure 1. Injection Frequency vs. DC Voltage*

2.6.4.2 The STEERING line is coupled from the rf board via J650-2 and the VCO interconnect plate. The plate contains the rf filters that shield the VCO. The STEERING line dc voltage level determines the capacitance of diodes CR1401, CR1402, CR1403, and CR1404 (which control the receive oscillator frequency) and CR1411, CR1412, CR1413, and CR1414 (which control the transmit oscillator frequency). An increase in the STEERING line voltage causes the capacitance of these diodes to decrease and the corresponding oscillator frequency to increase. On the other hand, a decrease in the STEERING line voltage causes an increase in the capacitance of the diodes and a reduction in the oscillator frequency.

2.6.5 Modulation Line

The transmit VCO is directly modulated by the transmit audio signals. This is achieved by using a second varactor diode circuit that employs CR1409 and CR1410. The transmit audio signal is coupled, via pin 4 of the VCO interconnect plate, to CR1410 whose function is to modulate the oscillator frequency. The second device, CR1409, is used to maintain the modulation level constant throughout the radio operating frequency range.

2.7 TRANSMIT AUDIO CIRCUITS

**NOTE**

While reading the following, refer to the IDC portion of the Common Circuits Board Schematic Diagram attached to the Common Circuits Board section of this manual.

2.7.1 The transmit audio circuits consist of four stages which condition the microphone audio signal for direct frequency modulation of the transmit injection signal. The greater part of the audio path is controlled by the IDC ENABLE signal that is coupled to the IDC (instantaneous deviation control) circuitry via J401-6. This signal controls transmission gate U501A, which enables the transmit audio circuits only when the radio is in the transmit mode (transmit +9.5 V is applied to the IDC ENABLE line).

2.7.2 The MIC HI signal is coupled into the pre-emphasis amplifier U502D via J401-5. This amplifier has a frequency response that enhances the audio frequencies toward the high end of the transmit audio frequency range (approximately 300-3000 Hz). The amplifier output (at U502-12) is coupled to U501-1. When PTT is activated, the transmission gate control line (at U501-13) switches to a high level and the signal passes through the gate to limiter/amplifier U502A.

2.7.3 The limiter/amplifier clips the audio signals at 7 volts peak-to-peak, thus preventing excessive audio modulation of the transmitted signal. (With lower audio input levels, this amplifier acts as a linear gain stage). The limited transmit audio signal is coupled from U502-3 to splatter filter stage U502C.

2.7.4 The splatter filter is a 3 kHz low-pass filter which removes higher-order harmonics from the audio signal. Having unity gain, this filter is used to attenuate high-frequency harmonics that are present on the clipped audio signal from the limiter stage. The splatter filter output passes from U502-10 to the deviation adjust potentiometer (R517).

2.7.5 External modulation, such as PL or DPL, passes through gates U501B and U501C. These gates are connected in series with the external modulation inputs, thus providing the capability of disabling these modulation inputs to circuits that may require such a function. Normally, these enable lines are pulled high by the HY501 resistors. The output of each gate passes to U502B via the resistors that form part of HY502.

2.7.6 Combiner U502B provides an output that is coupled to the compensation adjust potentiometer R543 and the reference oscillator. PL and DPL signals are used to frequency-modulate the reference oscillator, thus preventing the phase detector output from defeating the direct low-frequency modulation of the VCO generated by the PL/DPL signal. (The reference oscillator and phase detector form part of the synthesizer schematic diagram.) The audio signal at the wiper of R517 is combined with the PL/DPL signals at the compensation adjust potentiometer (R543). This combined signal then passes to the transmit VCO. The compensation adjust potentiometer, R543, is adjusted at the factory and should be readjusted only if the common circuits board, reference oscillator, or VCO is changed. R543 can be readjusted by following the procedure presented in the Radio Alignment and Adjustments part of the General Maintenance/ Troubleshooting section of this manual.

2.7.7 Reference Modulation Inhibit Switch Q502 is allowed to conduct while the radio is in the receive mode, effectively shorting the reference modulation signal line to ground. This prevents any noise induced on the line during the receive mode from affecting the reference oscillator and, consequently, the receive injection frequency. During initial turn-on, C508 is charged through Q502. This action allows a stable receive frequency to be attained almost immediately. Q502 is turned off by TX +9.5 V during transmit, enabling the reference modulation signal line.

## 3. SYNTHESIZER TROUBLESHOOTING PROCEDURE

### 3.1 GENERAL

3.1.1 Refer to EEPS-32258 which provides a comprehensive procedure for troubleshooting the frequency synthesizer.

3.1.2 The major problems that may occur in the frequency synthesizer are as follows:

- synthesizer does not lock
- synthesizer locks on wrong frequency
- excessive reference frequency feedthrough (spurs)
- noisy frequency lock
- slow switching response.

3.1.3 A summary of the problems and possible causes in a frequency synthesizer is provided in Table 2. Also refer to the other tables which provide pin connections and voltages for the phase detector, divider, prescaler, and super filter.

3.1.4 In the frequency synthesizer troubleshooting chart mention is made of an open loop test and checking of the divider programming. These two procedures are described in the following paragraphs and are not accompanied by a flowchart.

### 3.2 OPEN LOOP TEST

3.2.1 Introduction

3.2.1.1 The synthesizer troubleshooting chart refers to the open loop test. Use of the following equipment is required for this test: variable power supply, frequency counter, dual-trace oscilloscope, dc voltmeter, and rf voltmeter. Refer to the list of recommended test equipment provided in the GENERAL MAINTENANCE/TROUBLESHOOTING section of this manual.

3.2.1.2 The open loop test consists of four procedures:

- VCO frequency test
- loop and reference waveforms check
- phase detector check
- adaptive filter check.

### 3.2.2 VCO Frequency Test

Step 1. Remove jumper JU600 to open the STEERING LINE loop. Connect a 1 kilohm resistor to the plus terminal of a 0-10 V adjustable power supply and connect the free end of the resistor to the VCO side (at the point from which JU600 was removed, i.e., the side which is not connected to C637). Connect the negative terminal to A-. This power supply will serve as a steering line in this test.

Step 2. Connect a frequency counter to the divider port of the internal casting (P600). To check the transmit VCO, depress the PTT switch and monitor the frequency while slowly changing the steering voltage from 2.5 V to 9.0 V. Verify that the desired transmit frequency appears at some voltage in this range. If it does not, check the Bandshift 1 and 2 lines to the VCO at J650-5 and J650-6, respectively, and verify the proper state of each Bandshift line — Bandshift 1 should be low (0.2 V) and Bandshift 2 should be high (7.3 V) for frequencies from 150 MHz to 161.8 MHz. For frequencies from 161.8 MHz to 174 MHz, the state of the Bandshift lines will be reversed. If the Bandshift lines are OK, the VCO is faulty and should be replaced. Also check the output level at the VCO divider port (P/J600) and verify that it is greater than −15 dBm for the specified steering line voltage range (i.e., 1.0 to 9.6 V).

Step 3. The receive VCO is checked in a similar manner, as described in Step 2. The receive VCO output frequency will be 53.9 MHz higher than the desired receive frequency. With the radio in the receive mode, changing the steering line voltage from 2.5 V to 9.0 V should tune frequencies from 203.9 MHz to 215.5 MHz (the Bandshift 1 line should be high and the Bandshift 2 line low). When the state of the Bandshift lines is reversed, the VCO can be tuned to all frequencies from 215.5 MHz to 227.9 MHz by varying the steering line voltage. Also check the output level at the VCO divider port (P/J600) and verify that it is greater than -15 dBm for the specified steering line voltage range (i.e., 1.0 V to 9.6 V). If the Bandshift lines are OK and the output level to the divider port is adequate, but the desired receive injection frequency cannot be tuned by varying the steering line voltage, the VCO is faulty and should be replaced.

### 3.2.3 Loop and Reference Waveforms Check

Step 1. Connect one channel of a dual-trace oscilloscope to U602-5 (REF OUT) and the other to U602-9 (LOOP OUT). Adjust the oscilloscope so that it will trigger on the REFERENCE waveform. The oscilloscope trace should be in the chopped mode.

Step 2. Observe the LOOP waveform and verify that it is moving smoothly across the screen without any jitter when the steering line is varied from 1.0 V to 9.6 V.

Step 3. Observe the REFERENCE signal and verify that its period is correct without any jitter, and that one steering line voltage from 2.5 to 9.0 V does not exactly yield this period on the loop divider output. (The period depends on the customer's programming requirements.

*Table 2. Problems and Their Possible Causes in a SYNTOR X Synthesizer*

| Problems | Possible Source of Trouble |
|---|---|
| Synthesizer does not lock | refer to synthesizer troubleshooting chart. |
| Synthesizer locks on wrong frequency | reference oscillator (U608) frequency off (should be 14.4 MHz ±2 ppm). |
| **NOTE** A frequency error of 15.0 kHz, 30.0 kHz, or 45.0 kHz can be caused by a defective prescaler or by shorted or open programming lines from the divider to the prescaler (U601-7, U601-6). | erroneous divider programming from microcomputer (possible defective memory module, or code plug, or microcomputer). |
| | defective divider U602. |
| | defective prescaler U601. |
| Excessive reference frequency feedthrough (spurs) | defective hold capacitors C632, C633 (open or leaky). |
| | defective ramp capacitor C630. |
| | defective phase detector U603. |
| | adaptive filter in ADAPTIVE mode or shorted input to output; guard band shorted to VCO steering line or other adaptive filter mode. |
| Noisy frequency lock | marginal input level to prescaler (U601-1), loop divider (U602-25) or reference divider (U602-2). |
| | loose connection, cold solder joint, or faulty component. |
| | noisy Q603. |
| | defective phase detector U603. |
| | defective divider U602 or prescaler U601 (jittery). |
| | noisy 5 V or 9.6 V supplies. |
| | defective adaptive filter (open capacitors). |
| Slow switching response | improper synchronization from microcomuter. Check divider programming. |
| | malfunctioning adaptive filter, check U604, U605, U606. |
| | phase detector U603 gain too low (overdamped response) or too high (underdamped response); check R625, R626, RT600, C630, Q603. |
| | leaky adaptive filter capacitors or transmission gates (U605, U606, C641). |
| | leaky VCO varactor diodes. |

In most cases, it is 200 microseconds for 5 kHz reference.)

Step 4. If the conditons specified in Steps 2 and 3 are met, then the following must be checked: the divider buffer (Q602 and associated components), the prescaler (U601), the divider (U602), the reference oscillator (U608), and the divider programming. The prescaler can be checked by capacitively coupling a 200 MHz frequency counter to its output and verifying that the output is approximately one-third of the input frequency (or one-sixth the desired loop output frequency). A frequency counter will not provide an exact indication of one-third of the input frequency, since the prescaler is dividing by four part of the time. The difference should not exceed 50 ppm.

### 3.2.4 Phase Detector Check

The phase detector (U603) can be checked by adjusting the steering line voltage for a loop period slightly longer than the reference period and then for a slightly shorter period. With a longer loop period, the phase detector output (U603-15) should switch to a high state (greater than 9 V); with a shorter loop period, the phase detector output should switch to a low state (1.2 V). If this fails to happen, then the phase detector and associated circuitry should be checked.

### 3.2.5 Adaptive Filter Check

The adaptive filter can be checked for short or open circuits by removing jumper JU600 and then checking for a high voltage on the adaptive filter side when the base detector output is high. The absence of a high voltage is an indication of a faulty condition.

### 3.2.6 VCO Steering Line Leakage

**NOTE**

Be sure to use a shielded cable with the voltmeter when making these measurements.

The VCO steering line leakage can be checked by removing jumper JU600 and connecting a 1 megohm resistor to the VCO side. The free end of the resistor should be connected to an adjustable power supply set to 9.5 V. A high-impedance voltmeter (impedance greater than 10 megohms) should be used to verify that the voltage drop across the resistor is less than 18 mV. A higher voltage drop (greater than 18 mV) is an indication of either a leaky VCO interconnection plate or defective VCO steering line varactors (CR1401-1404, CR1409 and CR1411-1414). To determine which is defective, remove the VCO from the rf internal casting and perform the test again. If the voltage drop is greater than 2 millivolts, replace the interconnection plate.

*Table 3. Phase Detector (U603) Pin Connections and Voltages*

| Pin No. | Function | To/From | Nominal Voltage |
|---|---|---|---|
| 1 | high current ground | — | 0 V dc |
| 2 | REFERENCE IN | from U602-5 | 0 V to 4.3 V square wave (200 us period for 5 kHz ref freq) |
| 3 | LOW BANDWIDTH | from U602-17 | 0 V dc receive; 5 V dc transmit |
| 4 | SYNTHESIZER SYNC | to microcomputer | 60 us positive pulse 0-5 V at loop pulse rate; equal to pin 2 if pin 11 is low. |
| 5 | FREQUENCY CHANGE | from U602-18 | 0.5 V 11.1 us when frequency changes |
| 6 | no connection | | |
| 7 | ADAPT | to adaptive filter | 9.6 to 0.6 V single pulse, 3.0 ms (Rx) dekey; 15 ms (Tx) key. |
| 8 | TSW | to adaptive filter | 0 V dc receive, 9.6 V dc transmit |
| 9 | RSW | to adaptive filter | 9.6 V dc receive, 0 V dc transmit |
| 10 | ADAPT | to adaptive filter | 0-9.0 V single pulse, 3.0 ms (Rx) dekey; 15 ms (Tx) key. |
| 11 | LOCK | | 0 V dc when out of lock; 8 V dc when in lock. |
| 12 | HOLD 1 | CS11 | 1.4 to 8 V dc (use high input impedance voltmeter) |
| 13 | HOLD 2 | CS12 | 1.4 to 8 V dc (use high input impedance voltmeter) |
| 14 | A+ | | 9.6 V dc |
| 15 | PHASE DET OUTPUT | to adaptive filter | 1.2 to 9.5 V dc (depending on loop output frequency) |
| 16 | low current ground | | 0 V dc |
| 17 | EXT PNP BASE | to pnp Q604 base | 8.9 V dc |
| 18 | VCC | from regulator | 9.6 V dc |
| 19 | RAMP BASE | to pnp Q603 base (ramp generator | 9.1 V dc |
| 20 | FILTERED 9.1 V | to R624, R625, RT600, C629 | 9.1 V dc |
| 21 | RAMP RES | to R626, pnp Q603 emitter | 8.0 to 8.7 V dc rectangular wave @reference rate. |
| 22 | SAMPLE TIMING CAP. | to C631 | 0 to 2 V sawtooth wave at loop pulse rate. |
| 23 | LOOP IN PULSE | from U602-9 via C628 | 1.4 V pulse riding on 1.6 V dc (200 us, typical period) |
| 24 | RAMP CAP | from C630 and ramp pnp Q603 collector | flat top ramp waveform at reference rate, top voltage 1.4 to 7 V (depending on loop output frequency) |

*Table 4. Divider (U602) Pin Connections and Voltages*

| Pin No. | Function | To/From | Nominal Voltages |
|---|---|---|---|
| 1* | GND | | 0 V dc |
| 2 | REF IN | from U608 (reference oscillator) | 1.5 V dc +0.6 V pp ac (14.4 MHz) |
| 3 | 3.6 MHz OUT | NC | — |
| 4 | GND | | 0 V dc |
| 5* | REFERENCE OUT | to U603-2 (phase detector) | 0 to 4.3 V square wave (4.166, 5.0, or 6.25 kHz) |
| 6 | NC | | |
| 7 | NC | | |
| 8 | NC | | |
| 9* | LOOP OUT | to phase detector & prescaler | 2.9 V to 4.3 V narrow pulse (1.4 V pp) (200 us nominal period) |
| 10* | VCC | from regulator | 5 V dc |
| 11 | DØ | from microcomputer | 0 to 5 V pulse train |
| 12 | D1 | from mickocomputer | 0 to 5 V pulse train |
| 13 | D2 | from microcomputer | 0 to 5 V pulse train |
| 14 | D3 | from microcomputer | 0 to 5 V pulse train |
| 15 | CØ | to prescaler | 0 to 5 V dc |
| 16 | C1 | to prescaler | 0 to 5 V dc |
| 17 | LOW BANDWIDTH | to phase detector | 0 to 5 V dc |
| 18 | FREQ CHANGE | to phase detector | 0 to 5 V dc |
| 19 | VC01 | to TX-RX switching network | 0 to 0.7 V dc |
| 20 | VC02 | to band shift switching network | 0 to 0.7 V dc |
| 21 | NC | — | — |
| 22 | VBB | to divider | 1.5 V dc |
| 23 | AØ | from microcomputer | 0 to 5 V pulse train |
| 24 | A1 | from microcomputer | 0 to 5 V pulse train |
| 25 | PRESCALE IN | from prescaler | 1.5 V dc +0.7 V pp ac (approx. 50-80 MHz) |
| 26 | A2 | from microcomputer | 0 to 5 V pulse train |
| 27* | STROBE | from microcomputer | 0 to 5 V pulse train (7 pulses/train) |

*SHOULD BE CHECKED FIRST

*Table 5. Prescaler (U601) Pin Connections and Voltages*

| Pin No. | Function | To/From | Nominal Voltage |
|---|---|---|---|
| 1 | FIN | from VCO buffer | -12 to 0 dBm (at carrier or first injection freq.) riding on 3.8 V dc |
| 2 | VBB | | 3.8 V dc, bypassed for rf |
| 3 | PRESCALE OUT | to divider (U602) | 0 dBm (0.6 V pp) riding on dc level of 3.6 V dc at approx. one-third VCO freq. (±50 ppm) |
| 4 | GND | | 0 V dc |
| 5 | FV | from divider (U602) | 1.4 V p narrow pulse at reference freq. riding on 3.4 V dc |
| 6 | C1 | from divider | dc level (programming bit) 0 or 5 V dc; test memory module mode (4) 5 V dc; mode (5) 0 V dc |
| 7 | CØ | from divider | dc level (programming bit) 0 or 5 V dc; test memory module mode (4) 0 V dc; mode (5) 5 V dc |
| 8 | VCC | from regulator | +5.0 V ±0.1 V |

*Table 6. Super Filter Pin Connections and Voltages*

| Pin No. | Function | To/From | Nominal Voltage |
|---|---|---|---|
| 1 | VCC | from 9.6 V regulator | 9.6 V dc |
| 2 | FILTER CAP. | C603 | 7.1 V dc |
| 3 | EXT. DRIVER CONTROL | Q601 base | 8.9 V dc |
| 4 | 8.6 V OUT | to VCO switching | 8.6 V dc |
| 5 | Ground (internal NPN emitter) | from regulator | 0 V dc |
| 6 | Internal NPN collector | to VCO modulation | — |
| 7 | Internal NPN base | from VCO bandshift, R605, R606 | 0.2 V, transmit high range; 0.7 V, transmit low range |
| 8 | NC | | |

## 3.3 DIVIDER PROGRAMMING TEST

The synthesizer troubleshooting chart refers to the divider programming test. This test requires the use of a dual-trace oscilloscope and a test memory module (Motorola No. HLN1074A). Refer to the list of recommended test equpment provided in the GENERAL MAINTENANCE/TROUBLESHOOTING section in this manual. Refer to Table 4, which provides the pin numbers and functions of the divider (U602). Refer also to the timing diagram provided on the synthesizer troubleshooting chart which shows the waveforms generated under mode 4 of the test memory module.

Step 1. Connect channel 1 of a dual-trace oscilloscope to the STROBE line (U602-27) of the divider. Trigger the oscilloscope on the rising edge of the strobe signal.

Step 2. Connect channel 2 of the oscilloscope to the A0 line (U602-23) of the divider.

Step 3. Referring to the timing diagram on the troubleshooting chart, compare the waveforms observed on the oscilloscope with those shown in the timing diagram, and verify that the relationship between the STROBE and A0 signals is the same.

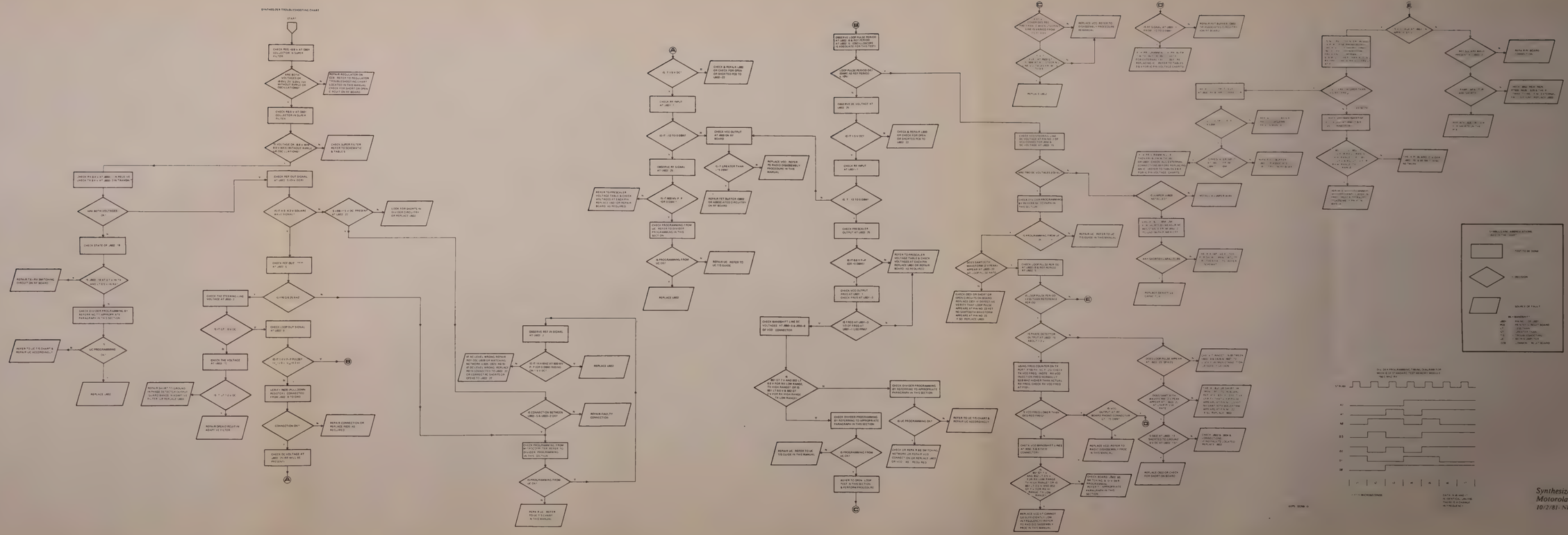
Step 4. Connect channel 2 of the oscilloscope to the A1 line (U602-24) and compare the pattern observed on the oscilloscope with the one shown in the timing diagram.

Step 5. Repeat the procedure until A2 (U602-26), D0 (U602-11), D1 (U602-12), D2 (U602-13), and D3 (U602-14) have been checked and verified.

Step 6. Verify that the prescaler "C" inputs are as shown in Table 5, and that the frequency at the receive injection port changes by 100 kHz when the mode is changed from mode 4 to mode 5. If these indications are incorrect, look for a short circuit or repair the circuit board runner or replace the prescaler (U601).

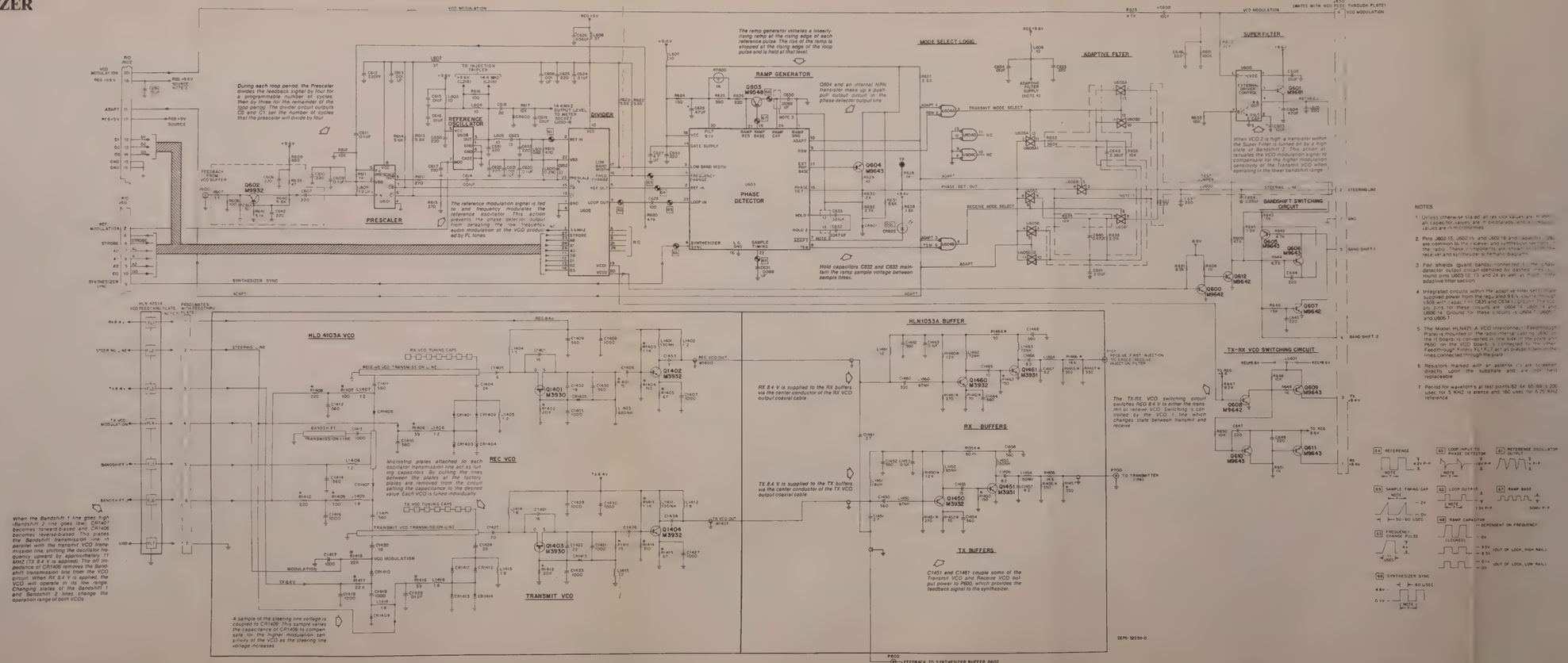
**NOTE**

An alternative method of checking the programming consists of using a single-trace oscillscope with an external trigger input. The external trigger can be connected to the strobe line and the strobe signal displayed on the oscilloscope to verify proper triggering (see timing diagram on the troubleshooting chart). Each of the address and data lines can then be checked as explained in Steps 1 through 5 presented above.


SYNTHESIZER TROUBLESHOOTING Chart
START
CHECK PS3 +8.8 V AT J860 COLLECTOR 'A' SUPPLY FILTER
ARE BOTH VOLTAGES OK (8.8V(+) TO 9.0V(+) AND +15.0V(+) TO +15.5V(+))?
REPAIR REGULATOR ON PS3. REFER TO REGULATION TROUBLESHOOTING CHART IN POWER SUPPLY SECTION OR CHECK FOR SHORT ON SPKR, IC ROUTING BY BOARD
CHECK PS3 0 V AT J860 COLLECTOR 'A' SUPPLY FILTER
IS VOLTAGE OK (8.8 V MIN, 9.4 V MAX) WITHOUT AUDIO DISTORTION?
CHECK SUPPLY FILTER REFER TO SCHEMATIC & TABLE 5
CHECK P3 8.4 V AT J860 AND P6 15 V AT J860 ON TRANSMIT
CHECK REF OUT SIGNAL AT J860 10 MHz SQUARE
ARE BOTH VOLTAGES OK?
IS J860-5 8.3 V SQUARE WAVE (~10 MHz)?
IS J860-5 3 V DC PRESENT AT J860 -5?
LOOK FOR SHORTS IN DIVIDER CIRCUITRY OR REPLACE J860
CHECK STATE OF J860 -19
IS J860 -19 AT 0 V OR 5 V (MIN.)?
REPAIR TX / RX SWITCHING CIRCUIT ON RF BOARD
CHECK DIVIDER PROGRAMMING BY REFERRING TO APPROPRIATE A/B PARAGRAPH IN THIS SECTION
I/O PROGRAMMING OK?
REFER TO I/O CHART & REPAIR I/C ACCORDINGLY
REPLACE J862
CHECK FEE BUF ??? AT J860
IS FEE (5.25 kHz)?
CHECK THE STEERING LINE VOLTAGE AT J860-3
IS VT OUT - 15V DC
CHECK LOOP OUT SIGNAL AT J860-3
CHECK THE VOLTAGE AT J860-15
IS VT OUT 0 V TO 7 V OUT?
REPAIR SHORT(S) CAUSING VOLTAGE DEFECT IN LOOP FILTER OR REPLACE J860
IS VT OUT 0 V TO 15 V OUT?
LEAKY / NON-PULL-DOWN RESISTOR / CONNECTED FROM J860 -15 TO GND
REPAIR OPEN(S) IN OUT IN ADAPT. I/C FILTER
CONNECTION OK?
REPAIR CONNECTION OR REPLACE J860 AS REQUIRED
CHECK 5E VOLTAGE AT J860 -15 (RT BELL 5E PRESENT)
A
OBSERVE REF IN SIGNAL AT J860 -2
IS IT 10 +-50HZ AT 800 MV P-P (OR 0.5MV RMS)?
REPLACE J860
IF NO LEVEL WRONG, REPAIR RET TO C856 OR MATCHING NETWORK (L805, C821, R878). IF NO LEVEL WRONG, REPLACE J860 (IF SHORTED) OR CORRECT PC SHORTS TO OPENS TO J860 -27
IS CONNECTION BETWEEN J860 -5 & J860 -2 OK?
REPAIR FAULTY CONNECTION
CHECK PROGRAMMING RO FROM I/C (REFER TO SECTION IV DIVIDER PROGRAMMING IN THIS SECTION)
IS PROGRAMMING FROM I/C OK?
REPAIR PROGRAMMING FROM I/C. REFER TO I/C TS GUIDE IN THIS MANUAL
REPLACE I/C. REFER TO I/C CHART IN THIS MANUAL
A
IS -7.5 V DC?
CHECK & REPAIR L860 OR CHECK FOR OPEN OR SHORTED PCB TO J860 -27
CHECK RF INPUT AT J860 -1
IS IT -13 TO 0 DBM?
CHECK VCO OUTPUT AT J860 ON RF BOARD
OBSERVE RF SIGNAL AT J860 -29
IS IT LESS THAN -15 DBM?
REPLACE VCO. REFER TO RADIO DISASSEMBLY PROCEDURE IN THIS MANUAL
IS IT -1800 MV P-P OR LOWER?
REPAIR FET BUFFER Q862 OR ASSOCIATED CIRCUITRY ON RF BOARD
REPAIR TO PRESCALER VOLTAGE TABLE & CHECK VOLTAGES AT EACH PIN (+1.1MV) OR REPAIR BOARD AS REQUIRED
CHECK PROGRAMMING FROM I/C. REFER TO DIVIDER PROGRAMMING IN THIS SECT ION
IS PROGRAMMING FROM I/C OK?
REPAIR I/C. REFER TO I/C TS GUIDE
REPLACE U862
B
OBSERVE LOOP PULSE PERIOD AT J860 -5 & REFERENCE TO TEST PERIOD
LOOP PULSE PERIOD OK? (REFER TO TEST PERIOD)
OBSERVE DC VOLTAGE AT J860 -29
IS IT 1.5 V DC?
CHECK & REPAIR L860 OR CHECK FOR OPEN OR SHORTED PCB TO J860 -27
CHECK RF INPUT AT J860 -1
IS -1 TO 0 DBM?
CHECK PRESCALER OUTPUT AT J862 -25
IS IT 0.6 V P-P 125 +/-10MHz?
REFER TO PRESCALER VOLTAGE TABLE & CHECK VOLTAGES AT EACH PIN. REPLACE U861 OR REPAIR BOARD AS REQUIRED
CHECK VCO OUTPUT (RO) AT J860. CHECK PINS 27, J862 -2
IS IT 600 MV P-P TO 1.5 V P-P (RED) AT J862 -2 (-105 PRM)?
CHECK BANDSHIFT LINE DC VOLTAGES AT J860-6 & J860-8 OR VCO CONNECTION
IS IT -5 V AND J860 -7 5.0 V FOR 50 (LOW RANGE) TO HIGH RANGE? (OR IS J860 -7 5.0 V AND J860 -6 -5 V FOR 50 (LOW RANGE)?
CHECK DIVIDER PROGRAMMING BY REFERRING TO APPROPRIATE PARAGRAPH IN THIS SECTION
CHECK DIVIDER PROGRAMMING BY REFERRING TO APPROPRIATE PARAGRAPH IN THIS SECTION
REPAIR I/C. REFER TO I/C TS GUIDE IN THIS MANUAL
IS PROGRAMMING FROM I/C OK?
REFER TO I/C TS CHART & REPAIR I/C ACCORDINGLY
REFER TO OPEN / LOW LEVEL PROTECTION & MONITORING CIRCUITS
C
CHECK D15 REG VOLTAGE AT J860 -13 (+8.8 V DIRECT FROM PS3)
REPLACE VCO. REFER TO SYNTHESIZER TROUBLESHOOTING MANUAL
IS IT +8.8 V (MIN.)?
IS IT +8.8 V (MIN.)?
REPLACE L862
CHECK VCO FEEDBACK LINE DC VOLTAGE AT PIN NO. 7 OF J860 (+2.5 TO +4.5 V)
ARE TWO DC VOLTAGES OK?
CHECK VCO FEEDBACK LINE VOLTAGES AT J860 -7
CHECK D16 (+5 V PROGRAMMING V) AT PIN 9 OF J860 (+4.75 TO +5.25V)
IS +5 V PROGRAMMING FROM J? OK?
REPAIR I/C. REFER TO I/C TS GUIDE IN THIS MANUAL
QUESTIONABLE VOLTAGE(S) (2 V READ) APPEAR AT J860 -6 & -7?
CHECK LOOP PULSE PER I/O CHART (REFER TO TEST PERIOD)
CHECK DED OR SHORT OR OPEN IN VCO CIRCUITRY. REPLACE U861 IF DEFECTIVE. VERIFY THAT LOOP PULSE IS PRESENT AT J860 -5 BEFORE REPLACEMENT. REFER TO APPLICABLE A/B PRI NO. IN P. SEC REPLACE J860
IS LOOP PULSE PER I/O CHART (REFERENCE)?
IS PHASE DETECTION OCCURRING AT J860 -15 & -16?
USING FREQ COUNTER ON TP PORT 1 FOR HI, SET TO CHECK FREQ. (NOTE: KS ±100 HZ, K1 ±1 KHZ, K2 ±10 KHZ, K3 ±100 KHZ, K4 ±1 MHZ) REFER TO FREQ CHECK FOR VCO FREQ AT P1201
IS VCO FREQ (ONLY THAT) AS INDICATED?
IS VCO OUTPUT AT J860 -5 PRESENT (CONNECTED TO VCO)?
REPLACE VCO. REFER TO RADIO DISASSEMBLY PROCEDURE IN THIS MANUAL
CHECK VCO BANDSHIFT LINES AT J860, 7 & 8 FOR CONNECTION
ARE BOTH OK? (-5 V FOR LOW RANGE, 5 V FOR HIGH RANGE) (-5 V AND 5 V FOR 50 (LOW RANGE)
REPLACE BOARD. REFER TO SM TSG NO. 6 OR SM TSG NO. 7 FOR VCO. REFER TO APPROPRIATE PARAGRAPH IN THIS SECTION
REPLACE VCO (IT CANNOT SWITCH BANDS). LOW VOLTAGE MAY BE CAUSED BY BAD I/O PAD OR SHORT/LEAKY PROC IN THIS MANUAL
D
IS RF SIGNAL AT J860 -1 TO -13 DBM?
REPAIR FET BUFFER Q862
IS RF SIGNAL AT J860 -1 TO -13 DBM?
REPLACE VCO. REFER TO RADIO DISASSEMBLY PROCEDURE IN THIS MANUAL
CHECK VCO FEEDBACK LINE VOLTAGES AT J860 -7 AND -8 FOR CORRECT VOLTAGE. REFER TO TABLES 3 & 4 FOR A PIN VOLTAGE CHARTS
ARE TWO DC VOLTAGES OK?
IS LOOP IN LOCK? (LOCK LED ON)
REPLACE U862
CHECK D16 (+5 V PROGRAMMING V) AT PIN 9 OF J860 (+4.75 TO +5.25V)
IS +5 V PROGRAMMING FROM J? OK?
REPAIR I/C. REFER TO I/C TS GUIDE IN THIS MANUAL
QUESTIONABLE VOLTAGE(S) (2 V READ) APPEAR AT J860 -6 & -7?
CHECK LOOP PULSE PER I/O CHART (REFERENCE)
IS LOOP PULSE PRESENT AT J860 -5?
CHECK VCO FEEDBACK LINE VOLTAGES AT J860 -7 & -8 FOR CORRECT VOLTAGE. REFER TO TABLES 3 & 4 FOR A PIN VOLTAGE CHARTS
ARE TWO DC VOLTAGES OK?
IS LOOP IN LOCK? (LOCK LED ON)
REPLACE U862
CHECK D16 (+5 V PROGRAMMING V) AT PIN 9 OF J860 (+4.75 TO +5.25V)
IS +5 V PROGRAMMING FROM J? OK?
REPAIR I/C. REFER TO I/C TS GUIDE IN THIS MANUAL
QUESTIONABLE VOLTAGE(S) (2 V READ) APPEAR AT J860 -6 & -7?
CHECK LOOP PULSE PER I/O CHART (REFERENCE)
IS LOOP PULSE PRESENT AT J860 -5?
CHECK VCO FEEDBACK LINE VOLTAGES AT J860 -7 & -8 FOR CORRECT VOLTAGE. REFER TO TABLES 3 & 4 FOR A PIN VOLTAGE CHARTS
ARE TWO DC VOLTAGES OK?
IS LOOP IN LOCK? (LOCK LED ON)
REPLACE U862
E
IS 5 V SUPPLY AT J860 -13 OK?
REPAIR FET BUFFER Q862
IS 5 V SUPPLY AT J860 -13 OK?
REPLACE VCO. REFER TO RADIO DISASSEMBLY PROCEDURE IN THIS MANUAL
CHECK VCO FEEDBACK LINE VOLTAGES AT J860 -7 & -8 FOR CORRECT VOLTAGE. REFER TO TABLES 3 & 4 FOR A PIN VOLTAGE CHARTS
ARE TWO DC VOLTAGES OK?
IS LOOP IN LOCK? (LOCK LED ON)
REPLACE U862
CHECK D16 (+5 V PROGRAMMING V) AT PIN 9 OF J860 (+4.75 TO +5.25V)
IS +5 V PROGRAMMING FROM J? OK?
REPAIR I/C. REFER TO I/C TS GUIDE IN THIS MANUAL
QUESTIONABLE VOLTAGE(S) (2 V READ) APPEAR AT J860 -6 & -7?
CHECK LOOP PULSE PER I/O CHART (REFERENCE)
IS LOOP PULSE PRESENT AT J860 -5?
CHECK VCO FEEDBACK LINE VOLTAGES AT J860 -7 & -8 FOR CORRECT VOLTAGE. REFER TO TABLES 3 & 4 FOR A PIN VOLTAGE CHARTS
ARE TWO DC VOLTAGES OK?
IS LOOP IN LOCK? (LOCK LED ON)
REPLACE U862
CHECK D16 (+5 V PROGRAMMING V) AT PIN 9 OF J860 (+4.75 TO +5.25V)
IS +5 V PROGRAMMING FROM J? OK?
REPAIR I/C. REFER TO I/C TS GUIDE IN THIS MANUAL
QUESTIONABLE VOLTAGE(S) (2 V READ) APPEAR AT J860 -6 & -7?
CHECK LOOP PULSE PER I/O CHART (REFERENCE)
IS LOOP PULSE PRESENT AT J860 -5?
CHECK VCO FEEDBACK LINE VOLTAGES AT J860 -7 & -8 FOR CORRECT VOLTAGE. REFER TO TABLES 3 & 4 FOR A PIN VOLTAGE CHARTS
ARE TWO DC VOLTAGES OK?
IS LOOP IN LOCK? (LOCK LED ON)
REPLACE U862
E
IS +5 V SUPPLY AT J860 -13 OK?
REPAIR FET BUFFER Q862
IS +5 V SUPPLY AT J860 -13 OK?
REPLACE VCO. REFER TO RADIO DISASSEMBLY PROCEDURE IN THIS MANUAL
CHECK VCO FEEDBACK LINE VOLTAGES AT J860 -7 & -8 FOR CORRECT VOLTAGE. REFER TO TABLES 3 & 4 FOR A PIN VOLTAGE CHARTS
ARE TWO DC VOLTAGES OK?
IS LOOP IN LOCK? (LOCK LED ON)
REPLACE U862
CHECK D16 (+5 V PROGRAMMING V) AT PIN 9 OF J860 (+4.75 TO +5.25V)
IS +5 V PROGRAMMING FROM J? OK?
REPAIR I/C. REFER TO I/C TS GUIDE IN THIS MANUAL
QUESTIONABLE VOLTAGE(S) (2 V READ) APPEAR AT J860 -6 & -7?
CHECK LOOP PULSE PER I/O CHART (REFERENCE)
IS LOOP PULSE PRESENT AT J860 -5?

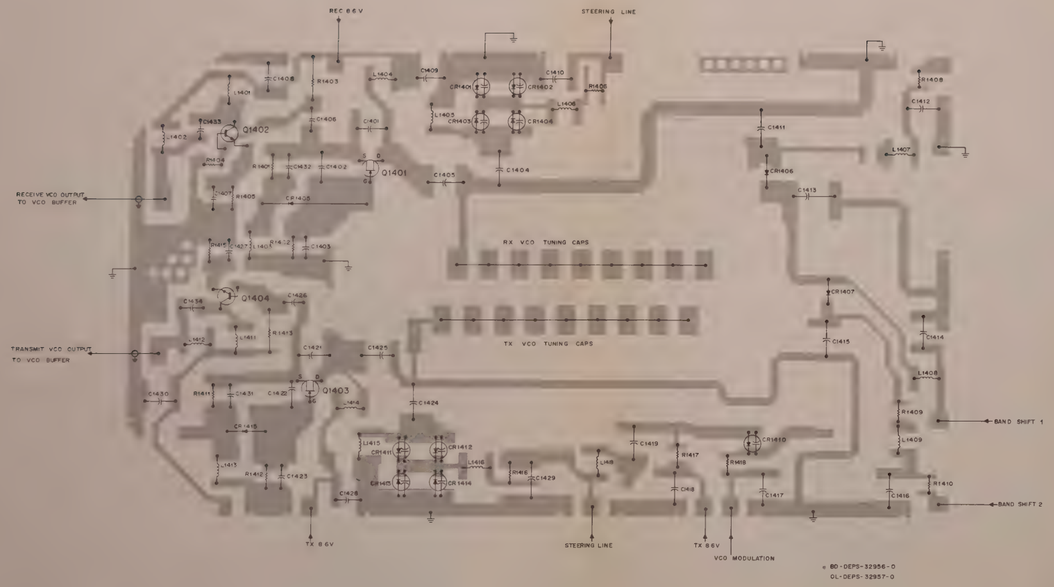
# FREQUENCY SYNTHESIZER

SCHEMATIC DIAGRAM



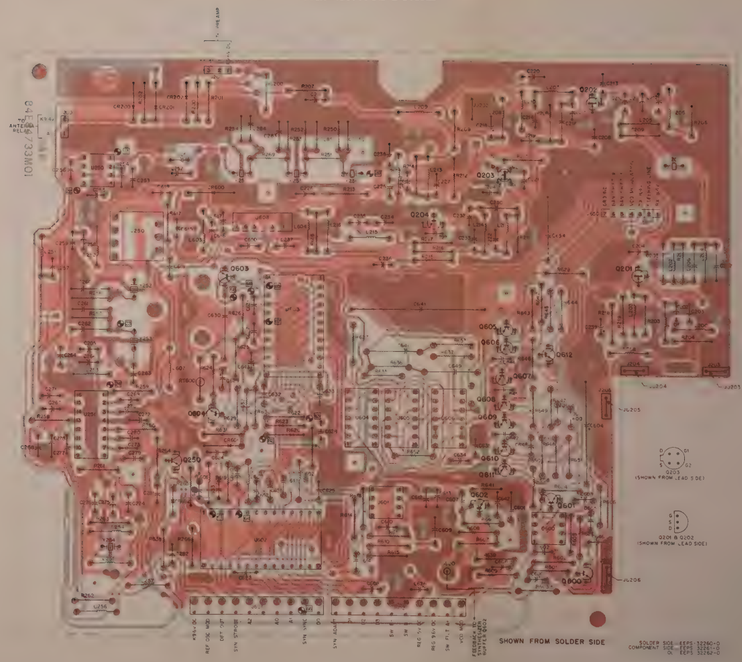

*Frequency Synthesizer Schematic Diagram, Circuit Board Detail, and Parts List*
*Motorola No. PEPS-32263-O*
*(Sheet 1 of 3)*
*10 2 81- NPC*

## HLD4103A VCO PCB

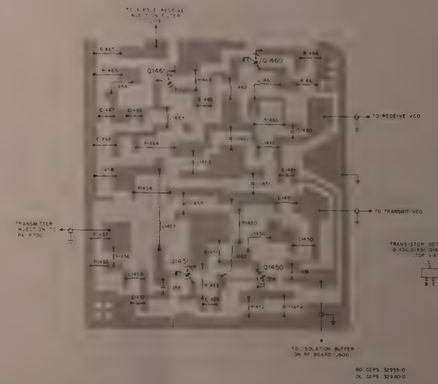



* 80-DEPS-32956-O
01-DEPS-32957-O

## HLN4239A RF BOARD




## HLN1053A VCO BUFFER PCB


TO RECEIVE VCO
TO TRANSMIT VCO
TRANSMITTER OUTPUT FROM PA PCB
TO ISOLATION BUFFER ON RF BOARD (J600)
TRANSISTOR DETAIL FOR Q460,Q470,Q1460,Q1461 (TOP VIEW)

80-DEPS-32955-O
01-DEPS-32960-O

*Frequency Synthesizer Schematic Diagram, Circuit Board Detail, and Parts List Motorola No. PEPS-32263-O (Sheet 2 of 3)*
*10-2-81-NPC*

# parts list

HLN4239A RF Board (Synthesizer Section) PL-7617-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **capacitor, fixed: uF ± 10%, 100 V; unless otherwise stated** |
| C600 | 23-11013C54 | 10 ± 20%; 15 V |
| C601 | 21-11014H36 | 30 pF ± 5% |
| C602 | 21-11015A07 | .01 + 80-20% |
| C603 | 23-11013C54 | 10 ± 20%; 15 V |
| C604 | 23-8278383 | 47 ± 20%; 20 V |
| C605 | 21-11015B05 | 220 pF |
| C606 | 21-11015B05 | 220 pF |
| C607 | 21-11015B05 | 220 pF |
| C608 | 21-11015B13 | .001 |
| C609 | 8-11017B17 | 0.1, 50 V |
| C610 | 21-11015B05 | 220 pF |
| C611 | 8-11017B17 | 0.1, 50 V |
| C612 | 21-11015B05 | 220 pF |
| C613, 614 | 21-11015B13 | .001 |
| C615 | 21-11015A07 | .01 + 80-20% |
| C616 | 21-11015A07 | .01 + 80-20% |
| C617 | 21-11015B05 | 220 pF |
| C618 | 21-11014H32 | 20 pF ± 5% |
| C619 | 21-11015A07 | .01 + 80-20% |
| C620 | 8-11017B17 | 0.1, 50 V |
| C621 | 21-11015B13 | .001 |
| C622 | 21-11015B05 | 220 pF |
| C623 | 21-8220458A1 | 13 pF ± 5% |
| C624 | 8-11017B17 | 0.1, 50 V |
| C625 | 21-11015B05 | 220 pF |
| C626 | 23-8453BG24 | 0.56, 35 V |
| C627 | 23-11013C55 | 4.7 ± 20%; 20 V |
| C628 | 21-11015B01 | 100 pF |
| C629 | 23-8453BG06 | 47, 20 V |
| C630 | 8-80027B03 | .0082 |
| C631 | 8-11017B07 | .0068, 50 V |
| C632 | 8-11017B06 | .0047, 50 V |
| C633 | 8-11017B01 | .001, 50 V |
| C634 | 21-11015A07 | .01 + 80-20% |
| C635 | 21-11015B05 | 220 pF |
| C637 | 21-11015B05 | 220 pF |
| C640 | 8-8463TL42 | 0.47 ± 5% |
| C641 | 8-8386ZM02 | 2.0 |
| C642 thru 648 | 21-11015B05 | 220 pF |
| C649 | 8-8463TL39 | 0.39 |
| C650, 651 | 21-11015B05 | 220 pF |
| C652 | 21-11014H33 | 22 pF ± 5% |
| C653 | 21-11015B05 | 220 pF |
| C654 | 8-80027B04 | .039 |
| | | **diode: (see note)** |
| CR600 | 48-82139G01 | germanium |
| CR601 | 48-83329G02 | silicon; 4 diode stack |
| CR602 | 48-84404E01 | light emitting, red |
| | | **connector, receptacle:** |
| J600 | 9-84231B02 | phono female (board mounting) |
| J601, 602 | 9-83445L09 | female, 10 contact |
| J650 | 9-83730M01 | female, 7 contact |
| | | **coil, rf:** |
| L600 | 24-82723H28 | 0.29 uHy |
| L601 | 24-83397L13 | 0.82 uHy |
| L602 | 24-83961B01 | 3 turns; coded BRN |
| L603, 604 | 24-82723H07 | 10 uHy |
| L605 | 24-83397L07 | 10 uHy |
| L606 | 24-83961B01 | 3 turns; coded BRN |
| L607, 608 | 24-82723H07 | 10 uHy |
| L609 | 24-83397L12 | 1.2 uHy |
| | | **transistor: (see note)** |
| Q600 | 48-869642 | NPN; type M9642 |
| Q601 | 48-869681 | PNP; type M9681 |
| Q602 | 48-869932 | NPN; type M9932 |
| Q603 | 48-869548 | PNP; type M9548 |
| Q604, 605, 606 | 48-869643 | PNP; type M9643 |
| Q607, 608 | 48-869642 | NPN; type M9642 |
| Q609, 610, 611 | 48-869643 | PNP; type M9643 |
| Q612 | 48-869642 | NPN; type M9642 |
| | | **resistor, fixed: ± 5%; 1/4 W; unless otherwise stated** |
| R601 | 6-11009C97 | 100k |
| R602 | 6-11009C81 | 22k |
| R603 | 6-11009C85 | 4.7k |
| R604 | 6-11009C49 | 1k |
| R605 | 6-11009C73 | 10k |
| R606 | 6-11009C89 | 47k |
| R607 | 6-11009C13 | 33 |
| R608 | 6-11009C25 | 100 |
| R609 | 6-11009C45 | 680 |
| R610 | 6-11009C35 | 270 |
| R611 | 6-11009C49 | 1k |
| R612 | 6-11009C73 | 10k |
| R613, 614 | 6-11009C87 | 5.6k |
| R615 | 6-11009C35 | 270 |
| R616 | 6-11009C25 | 100 |
| R617 | 6-11009C75 | 12k |
| R618 | — | NOT USED |
| R619 | 6-11009C41 | 470 |
| R620 | 6-11009C65 | 4.7k |
| R621 | 6-11009C71 | 8.2k |
| R622, 623 | 6-11009C87 | 5.6k |
| R624 | 6-11009C29 | 150 |
| R625 | 6-11009C39 | 390 |
| R626 | 6-11009C33 | 220 |
| R627 | 6-11009C57 | 2.2k |
| R628 | 6-11009C49 | 1k |
| R629 | 6-11009C01 | 10 |
| R630 | 6-11009C56 | 2k |
| R631 | 6-11009C67 | 5.6k |
| R632 | 6-11009C59 | 3.7k |
| R633 | — | NOT USED |
| R634 | — | NOT USED |
| R635 | 8-11009C75 | 12k |
| R636 | 6-11009C56 | 2.0k |
| R637 | 6-11009C37 | 2.2k |
| R638 | 6-11009C53 | 1.5k |
| R639 | 6-11009C17 | 47 |
| R640 | 6-11009C69 | 5.6k |
| R641 | 6-11009C66 | 5.1k |
| R642 | 6-11009C65 | 4.7k |
| R643 | 6-11009C19 | 56 |
| R644 | 6-11009C65 | 4.7k |
| R645, 646 | 6-11009C53 | 1.5k |
| R647 | 6-11009C71 | 8.2k |
| R648 | 6-11009C73 | 10k |
| R649 | 6-11009C49 | 1k |
| R650 | 6-11009C73 | 10k |
| R651 | 6-11009C49 | 1k |
| R652 | 6-11009D11 | 360k |
| R653 | 6-11009C77 | 15k |
| RT600 | 8-858402 | **thermistor:** 1k @ 25°C |
| U600 | 51-84768F85 | **integrated circuit (see note)** super filter; type M5865 |
| U601 | 51-84768F68 | prescaler; type M5868 |
| U602 | 51-839774A18 | divider; type M7718 |
| U602AH | 51-847682F65 | divider; type M5863 |
| U603 | 51-847682F59 | phase detector; type M5859 |
| U604 | 51-828841L04 | two input quad NOR gate; type M8404 |
| U605 | 51-80073C02 | quad analog switch; type M7302 |
| U606 | 51-80073C03 | quad analog switch; type M7303 |
| U608 | 51-80291B01 | rel osc; type M9101 |

HKN4067A VCO Buffer Cable PL-7630-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| P600, 700 | 28-82365D02 | male single contact |
| | | **mechanical parts** |
| | 1-80707T40 | ASSEMBLY COAXIAL CABLE; includes: |
| | 5-135025 | EYELET |
| | 30-83794C01 | CABLE, coax - refer port P600 |
| | 1-80707T41 | ASSEMBLY COAXIAL CABLE, includes: |
| | 5-135025 | EYELET |
| | 30-83794C01 | CABLE, coax |

HLD4103A VCO PL-7631-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **capacitor, fixed: pF ± 5%; 50 V; unless otherwise stated** |
| C1401 | 21-84736E08 | 16 |
| C1402 | 21-84736E14 | 18 |
| C1403 | 21-84873H13 | 1000 |
| C1404 | 21-84736E37 | 24 |
| C1405 | 21-84736E08 | 16 |
| C1406 | 21-84736E34 | 1 ± 0.25 pF |
| C1407, 1408 | 21-84547A01 | 1000 ± 20% |
| C1409 thru 1412 | 21-84873H14 | 560 |
| C1413 | 21-84873H13 | 1000 |
| C1414, 1415 | 21-84873H14 | 560 |
| C1416 thru 1419 | 21-84547A01 | 1000 ± 20% |
| C1420 | 21-84873H86 | 18 |
| C1421 | 21-84736E14 | 18 |
| C1422 | 21-84736E13 | 22 |
| C1423 | 21-84873H13 | 1000 |
| C1424 | 21-84736E12 | 39 |
| C1425 | 21-84736E35 | 20 |
| C1426 | 21-84736E34 | 1 ± 0.25 pF |
| C1427, 1428 | 21-84547A01 | 1000 ± 20% |
| C1429 | 21-84873H55 | .01 uF |
| C1430, 1431 | 21-84547A01 | 1000 ± 20% |
| C1432 | 21-84873H14 | 560 |
| C1433, 1434 | 21-84873H75 | 7 ± 0.25 pF |
| | | **diode: (see note)** |
| CR1401 thru 1404 | 48-82190H51 | silicon |
| CR1405 | 48-84616A01 | hot carrier |
| CR1406, 1407 | 48-84622E02 | silicon |
| CR1409 thru 1414 | 48-82190H51 | silicon |
| CR1415 | 48-84616A01 | hot carrier |
| | | **coil, rf:** |
| L1401 | 24-82091N06 | 130 nH |
| L1402 | 24-82091N01 | 1.2 uH |
| L1403 | 24-82091N07 | 680 nH |
| L1404 | 24-82091N08 | 1.5 uH |
| L1405 thru 1408 | 24-82091N01 | 1.2 uH |
| L1409 | 24-82091N02 | 1.8 uH |
| L1411 | 24-82091N06 | 130 nH |
| L1412 | 24-82091N02 | 1.8 uH |
| L1413 | 24-82091N01 | 1.2 uH |
| L1414 thru 1418 | 24-82091N02 | 1.8 uH |
| P650 | 9-83729M01 | **connector, receptacle:** female, 7 contact |
| Q1401 | 48-84939C30 | **transistor: (see note)** field-effect: type M3930 |
| Q1402 | 48-84939C32 | NPN; type M3932 |
| Q1403 | 48-84939C30 | field-effect: type M3930 |
| Q1404 | 48-84939C32 | NPN; type M3932 |
| R1401 thru 1418 | screened | **resistor, fixed:** see note 6 |
| W1400, 1401 | 30-80233C01 | **cable:** coaxial, 50 ohm |
| | | **mechanical part** |
| | 7-80162D01 | FRAME |

HLN4249A VCO Buffer PL-7626-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **capacitor, fixed: pF ± 5%, 50 V; unless otherwise stated** |
| C1450 | 21-84873H14 | 560 |
| C1451 | 21-84873H80 | 2.7 ± 0.25 pF |
| C1452 | 21-84873H14 | 560 |
| C1453 | 21-84547A24 | 0.1 uF ± 20%; 25 V |
| C1454 | 21-84873H14 | 560 |
| C1455 | 21-84873H97 | 15; 25 V |
| C1456, 1457 | 21-84873H56 | 8.2 ± 0.5 pF |
| C1458 | 21-84873H14 | 560 |
| C1459 | | NOT USED |
| C1460 | 21-84873H98 | 330 ± 10% |
| C1461 | 21-84873H60 | 2.7 ± 0.25 pF |
| C1462 | 21-84873H14 | 560 |
| C1463 | 21-84547A24 | 0.1 uF ± 20%; 25 V |
| C1464 | 21-84873H14 | 560 |
| C1465 | 21-84873H76 | 10 |
| C1466, 1467 | 24-84873H56 | 8.2 ± 0.5 pF |
| C1468 | 21-84873H14 | 560 |
| | | **coil, rf:** |
| L1450 | 24-05318D07 | 67 nH |
| L1451 | 24-05452C66 | choke; 1.8 uH |
| L1452 | 24-82723H13 | choke; 85 nH |
| L1453 | 24-82723H22 | choke; 150 nH |
| L1454 | 24-05452C09 | choke; 50 nH |
| L1460 | 24-05318D07 | 67 nH |
| L1461 | 24-05452C62 | choke; 1.2 uH |
| L1462, 1463 | 24-05452C38 | choke; 72 nH |
| L1464 | 24-05318D17 | 6 turns |
| P101 | 28-84227B04 | **connector, plug:** male, (phono) |
| | | **transistor: (see note 1)** |
| Q1450 | 48-84939C32 | NPN; type M3932 |
| Q1451 | 48-84939C31 | NPN; type M3931 |
| Q1460 | 48-84939C32 | NPN; type M3932 |
| Q1461 | 48-84939C31 | NPN; type M3931 |
| R1450 thru 1457 | screened | **resistor, fixed: (see note 6)** non-replaceable |
| R1460 thru 1467 | screened | non-replaceable |
| | | **mechanical part** |
| | 64-84854M01 | PLATE, buffer |

notes:
1. For optimum performance, diodes, transistors, and integrated circuits must be ordered by Motorola part number.
2. For parts not listed in the above parts list refer to the mechanical parts section.

*Frequency Synthesizer Schematic Diagram, Circuit Board Detail, and Parts List*
*Motorola No. PEPS-32263-O*
*(Sheet 3 of 3)*
*10/2/81- NPC*

## 1. DESCRIPTION

1.1 The *SYNTOR X* radio is a dual-conversion with intermediate frequencies of 53.9 MHz and 10.7 MHz. The factory-tuned preselector filter is sufficiently wide to accommodate all frequencies within the 150 MHz to 174 MHz band without retuning.

1.2 The receiver circuits are located in the rf internal casting, on the rf board, on the personality board, and on the common circuits board.

## 2. THEORY OF OPERATION

### 2.1 INTRODUCTION

2.1.1 The *SYNTOR X* radio does not employ channel elements to generate the first mixer injection frequency. Rather, the frequency synthesizer rf output is applied to the first mixer via a 3-pole injection filter. The first mixer, which is a balanced JFET (junction field-effect transistor) device, uses high-side injection to generate a first intermediate frequency (i-f) of 53.9 MHz.

2.1.2 The 53.9 MHz i-f signal is coupled from the first mixer to the rf board, via P/J203, and is then applied to the first i-f amplifier. This amplifier uses a JFET device in a common-gate configuration. The amplified output signal passes through a 53.9 MHz two-pole crystal filter and is then applied to a second i-f amplifier, so that it will have sufficient level to drive the second mixer.

2.1.3 The output of the frequency synthesizer's 14.4 MHz reference oscillator is split and part of the signal is applied to the injection tripler. The injection tripler uses a class-C bipolar transistor amplifier to generate the required harmonics. The injection tripler output is tuned at a fixed injection frequency of 43.2 MHz. The second mixer uses the two input signals to generate a second intermediate frequency of 10.7 MHz. Low-side injection is also used in the second mixer.

### 2.2 SECOND I-F CIRCUITRY

2.2.1 Several stages of filtering and amplification are employed in the second i-f circuitry. Selective i-f filtering is achieved by using dual-resonator, mode-coupled monolithic crystals cut to a fundamental frequency of 10.7 MHz. No tuning is required in the second i-f or detector circuitry.

2.2.2 The second mixer's output is applied to the 6-pole filter (Y250, Y251, Y255) via a matching network, and the output of the first 6-pole filter is applied to a matching network and then to a high-gain (approximately 45 dB) second i-f amplifier (U250). The output of the second i-f amplifier is applied to a matching network, a 4-pole filter (Y252-Y253), a final matching circuit, and the limiter/decoder (U251).

### 2.3 LIMITER/DETECTOR

The limiter/detector (U251) provides a limiting function and a means for recovering audio from the frequency-modulated carrier. Audio is recovered from the second i-f signal by means of a quadrature detector internal to the limiter/detector and an external two-pole dual resonator crystal. The recovered audio from the limiter/detector output passes through an emitter-follower buffer (Q250) and is then routed to the audio stages on the personality board (via the personality board and the control head). The detector buffer provides approximately 650 millivolts rms to the control head.

### 2.4 AUDIO AND SQUELCH

2.4.1 Detected audio is applied to the optional PL/DPL circuitry and is then routed to the control head for application to the volume and squelch controls. The adjustable outputs of these voltage dividers are then routed to the radio for application to the respective audio and squelch circuits.

2.4.2 The incoming signals are buffered and filtered by the PL filter/audio shaping stages to remove any receive PL tones. These stages consist of quad

operational amplifier U440 and associated circuitry up to the input of the audio driver (U441). The audio power amplifier consists of audio driver U441, the driver transistor pairs, and the class-B complementary audio finals, Q448 and Q449. The audio power amplifier amplifies the filtered audio signals, and the amplified audio signal is then transformer-coupled to the external speaker. The transmit time-out-timer tone and any tones from the *Systems 90* board are also injected at the input of the audio power amplifier stage.

2.4.3 Squelch muting is controlled at two points: at series-connected FET Q442 in the PL filter and shunt transistor Q441 on the volume wiper line. Q442 is used for squelch muting as well as for muting in the priority-*Channel Scan* mode while sampling the priority channel. The MUTE line drives not only transistor Q441 but also the audio driver enable switch Q447. When the audio driver is disabled, the bias current to the audio finals is removed, thus causing a substantial reduction of the current drawn by the radio when in the standby mode.

## 2.5 SQUELCH OPERATION

2.5.1 The buffered detector output signal level is varied by the squelch control on the control head. This signal, a combination of noise and recovered audio, is shaped by the squelch circuitry. Good squelch characteristics are obtained by using:

- a high-pass filter that precedes the first amplifier to attenuate the audio frequencies to a specific level.
- capacitors C403 and C404 which attenuate noise with frequencies higher than 22 kHz to provide a band of noise susceptible to detection.
- an input network to the detector that provides further attenuation of audio and any harmonics generated by audio limiting at the output of the second amplifier/limiter.

2.5.2 The filtered noise is routed to a positive-peak detector which provides negative-going spikes at its output. These spikes are forwarded to the integrator and the variable squelch tail control circuitry. The integrator compares the average dc level of the detector's output with a reference level and provides a fast responding output signal, $V_o$, as follows: $V_o$ will be greater than 4.5 V for squelched, and less than 4.5 V for unsquelched.

2.5.3 THe detector's output is also routed to Q402 via a dual time-constant network consisting of R416, CR403, and R417. If the signal is weak or in the absence of a signal, the noise spike rate becomes sufficiently high to keep C410 discharged below the turn-on voltage of Q402, thus causing its collector to have a potential of +9.6 V. When the signal level increases, Q402 turns on and its collector voltage, $V_o$, begins to decrease. With a strong signal, the collector voltage reaches a minimum level of approximately 4 V. For a given level at the integrator output, the voltage across C411 varies directly with $V_o$ of Q402.

2.5.4 Q403 generates an output signal (SQUELCH TAIL) that is a delayed and inverted version of the integrator output. The microcomputer mutes the audio when the SQUELCH TAIL signal goes low (0 V) and unmutes the audio when the signal goes high (4.8 V). The Q403 turn-on voltage at the node between R418 and R422 is approximately 4.5 V. This voltage is determined by the 9.6 V supply, R420, C411, and the dual time-constant network comprising R418, R419, and CR404.

2.5.5 With loss of signal, the greater the voltage across C411, the longer it will take the node voltage (R418 and R422) to increase above 4.5 V, and thus the longer it will take the SQUELCH TAIL signal to remain high after loss of signal. Since C411 charges through R419 and CR404, the SQUELCH TAIL detect time is considerably fast. The integrator output is also inverted by Q404 and provided as a CHANNEL ACTIVITY signal. This is a fast-responding output signal that is used only in *Channel Scan* operation.

## 2.6 RECEIVER METERING SOCKET

The receiver metering socket (J250) permits the following measurements to be made:

- MS1 (pin 1 of the metering socket) provides an indication of the i-f signal frequency relative to the quadrature detector center frequency.

**NOTE**
This should not be used for "warping" the radio on frequency.

- MS2 permits monitoring of the i-f signal level at the input of the limiter/detector.
- MS3 allows monitoring of the second mixer bias current, the proper injection level, and the high-level rf signals at the second mixer output.
- MS4 allows the measurement of the strength of the 14.4 MHz signal generated by the reference oscillator.
- MS5 permits monitoring the dc current to the first mixer.

*Table 1. Receiver Preliminary Checks*

| Pin On Metering Socket (J250) on RF Board | Normal Indication | If Indication Is Incorrect |
|---|---|---|
| J250-1 | 25 ±5 uA | Check the low i-f and quad detector. (See Note after Step 2.) |
| J250-2 | a. (without signal): 20 ±5 uA<br>b. (with 20 dB quieting signal): should be 2 to 5 uA above first signal | Go to Step 2 (para. 3). |
| J250-3 | a. 27 ±5 uA | a. Check Q203 dc voltages. |
| | b. (When Q204 base is shorted) reading should drop 2-3 uA. | b. Check Q203 and Q204 dc voltages |
| J250-4 | Greater than 10 uA | Check reference oscillator output level. |
| J250-5 | a. 25-40 uA | a. Check 1st mixer for proper dc voltages. |
| | b. Short injection filter output to ground; reading should drop at least 20%. | b. Insufficient low output drive; check VCO and buffer. |

## 3. RECEIVER TROUBLESHOOTING PROCEDURE

This procedure facilitates the location of the cause of sensitivity loss in the *SYNTOR X* radio. Refer to the list of Recommended Test Equipment provided in the General Maintenance section of this manual.

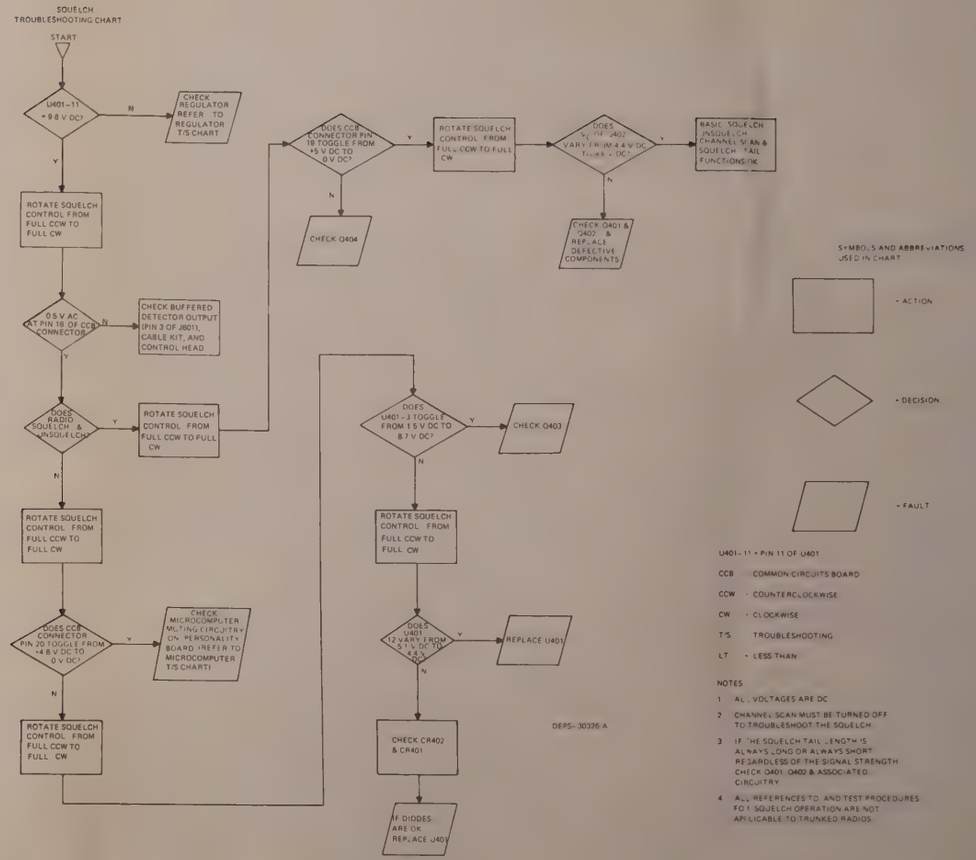
Step 1. Perform the preliminary checks provided in Table 1. If all the meter indications are correct, go to Step 2.

Step 2. Apply a 20-millivolt signal to the antenna connector. If the meter indication at J250-3 rises above 35 uA, check the low i-f (intermediate frequency) amplifiers, filters, and quadrature detector.

**NOTE**

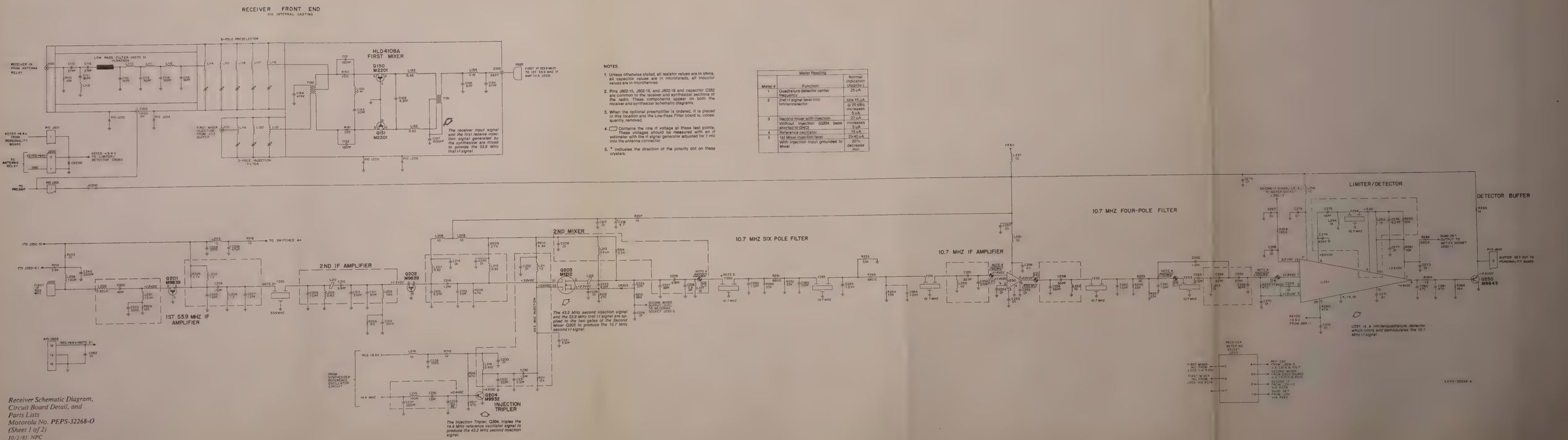
Troubleshooting of the low i-f and detector is facilitated by referring to the meter voltages, rf voltages, and dc voltages provided in the receiver schematic diagram located at the end of this section.

If the meter indication at J250-3 is less than 35 uA, check the dc voltages of the high i-f (Q201, Q202, Q203, and Q204).


SQUELCH TROUBLESHOOTING CHART
START
U401-11 = 9.8 V DC?
N
CHECK REGULATOR REFER TO REGULATOR T/S CHART
Y
ROTATE SQUELCH CONTROL FROM FULL CCW TO FULL CW
0.5 V AC AT PIN 18 OF CCB CONNECTOR
N
CHECK BUFFERED DETECTOR OUTPUT (PIN 3 OF J6011, CABLE KIT, AND CONTROL HEAD
Y
DOES RADIO SQUELCH & UNSQUELCH?
Y
ROTATE SQUELCH CONTROL FROM FULL CCW TO FULL CW
N
ROTATE SQUELCH CONTROL FROM FULL CCW TO FULL CW
DOES CCB CONNECTOR PIN 20 TOGGLE FROM +4.8 V DC TO 0 V DC?
Y
CHECK MICROCOMPUTER MUTING CIRCUITRY ON PERSONALITY BOARD (REFER TO MICROCOMPUTER T/S CHART)
N
ROTATE SQUELCH CONTROL FROM FULL CCW TO FULL CW
DOES CCB CONNECTOR PIN 19 TOGGLE FROM +5 V DC TO 0 V DC?
Y
ROTATE SQUELCH CONTROL FROM FULL CCW TO FULL CW
DOES V_CC OF Q402 VARY FROM 4.4 V DC TO 8 V DC?
Y
BASIC SQUELCH (UNSQUELCH, CHANNEL SCAN & SQUELCH TAIL FUNCTIONS) OK
N
CHECK Q401 & Q402 & REPLACE DEFECTIVE COMPONENTS
N
CHECK Q404
DOES U401-3 TOGGLE FROM 1.5 V DC TO 8.7 V DC?
Y
CHECK Q403
N
ROTATE SQUELCH CONTROL FROM FULL CCW TO FULL CW
DOES U401 12 VARY FROM 5.1 V DC TO 8.5 V DC?
Y
REPLACE U401
N
CHECK CR402 & CR401
IF DIODES ARE OK REPLACE U401
EEPS-30326-A
SYMBOLS AND ABBREVIATIONS USED IN CHART
= ACTION
= DECISION
= FAULT
U401-11 = PIN 11 OF U401
CCB = COMMON CIRCUITS BOARD
CCW = COUNTERCLOCKWISE
CW = CLOCKWISE
T/S = TROUBLESHOOTING
LT = LESS THAN
NOTES
1 ALL VOLTAGES ARE DC
2 CHANNEL SCAN MUST BE TURNED OFF TO TROUBLESHOOT THE SQUELCH
3 IF THE SQUELCH TAIL LENGTH IS ALWAYS LONG OR ALWAYS SHORT REGARDLESS OF THE SIGNAL STRENGTH CHECK Q401, Q402 & ASSOCIATED CIRCUITRY
4 ALL REFERENCES TO AND TEST PROCEDURES FOR SQUELCH OPERATION ARE NOT APPLICABLE TO TRUNKED RADIOS

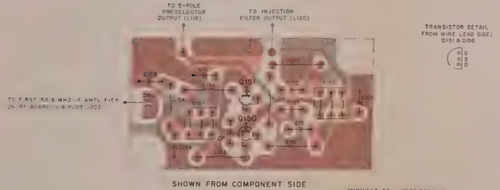
*Squelch Troubleshooting Chart*
*Motorola No. EEPS-30326-A*
*10-2-81-NPC*

# RECEIVER SCHEMATIC DIAGRAM

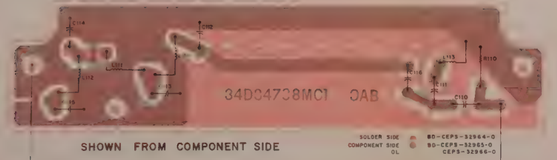

RECEIVER FRONT END
P/O INTERNAL CASTING
RECEIVER IN FROM ANTENNA RELAY
LOW PASS FILTER (NOTE 3)
HLN4200A
3-POLE PRESELECTOR
HLD4108A
FIRST MIXER
Q150
M2201
Q151
M2201
FIRST IF (53.9 MHZ) TO 1ST 53.9 MHZ IF AMPLIFIER (J203)
3-POLE INJECTION FILTER
FIRST MIXER INJECTION FROM VCO BUFFER
P/O J202
P/O J204
P/O J205
P/O J206
P/O J401
KEYED +9.6 V FROM PERSONALITY BOARD
P/O ANTENNA RELAY
KEYED +9.6 V TO LIMITER/ DETECTOR CR260
TO PREAMP
P/O J201
A1200
The receiver input signal and the first receive injection signal generated by the synthesizer are mixed to provide the 53.9 MHz first i-f signal.
NOTES.
1. Unless otherwise stated, all resistor values are in ohms, all capacitor values are in microfarads, all inductor values are in microhenries
2. Pins J602-15, J602-16, and J602-18 and capacitor C282 are common to the receiver and synthesizer sections of the radio. These components appear on both the receiver and synthesizer schematic diagrams.
3. When the optional preamplifier is ordered, it is placed in this location and the Low-Pass Filter board is, consequently, removed.
4. Contains the rms rf voltage at these test points. These voltages should be measured with an rf voltmeter with the rf signal generator adjusted for 1 mV into the antenna connector.
5. * Indicates the direction of the polarity dot on these crystals.
Meter Reading
Meter # | Function | Normal Indication (Approx.)
1 | Quadrature detector center frequency | 25 uA
2 | 2nd i-f signal level into limiter/detector | Idle 15 µA @ 20 dBq increases 5 uA
3 | Second mixer with injection Without injection (Q204 base shorted to GND) | 27 uA increases 5 uA
4 | Reference oscillator | 15 uA
5 | 1st Mixer injection level With injection input grounded to Mixer | 25-40 uA 20% decrease min
1ST 53.9 MHZ IF AMPLIFIER
Q201 M9639
Q202 M9639
2ND IF AMPLIFIER
2ND MIXER
Q203 M2112
The 43.2 MHz second injection signal and the 53.9 MHz first i-f signal are applied to the two gates of the Second Mixer Q203 to produce the 10.7 MHz second i-f signal.
10.7 MHZ SIX POLE FILTER
10.7 MHZ IF AMPLIFIER
10.7 MHZ FOUR-POLE FILTER
LIMITER/DETECTOR
DETECTOR BUFFER
Q250 M9645
U251 is a limiter/quadrature detector which limits and demodulates the 10.7 MHz i-f signal
P/O J602
REG +9.6V (NOTE 2)
FROM SYNTHESIZER REFERENCE OSCILLATOR CIRCUIT
14.4 MHZ
INJECTION TRIPLER
Q204 M9932
The Injection Tripler, Q204, triples the 14.4 MHz reference oscillator signal to produce the 43.2 MHz second injection signal.
RECEIVER METER NO. SOCKET J2250
EEPS-32264-A

*Receiver Schematic Diagram, Circuit Board Detail, and Parts Lists Motorola No. PEPS-32268-O (Sheet 1 of 2) 10/2/81- NPC*

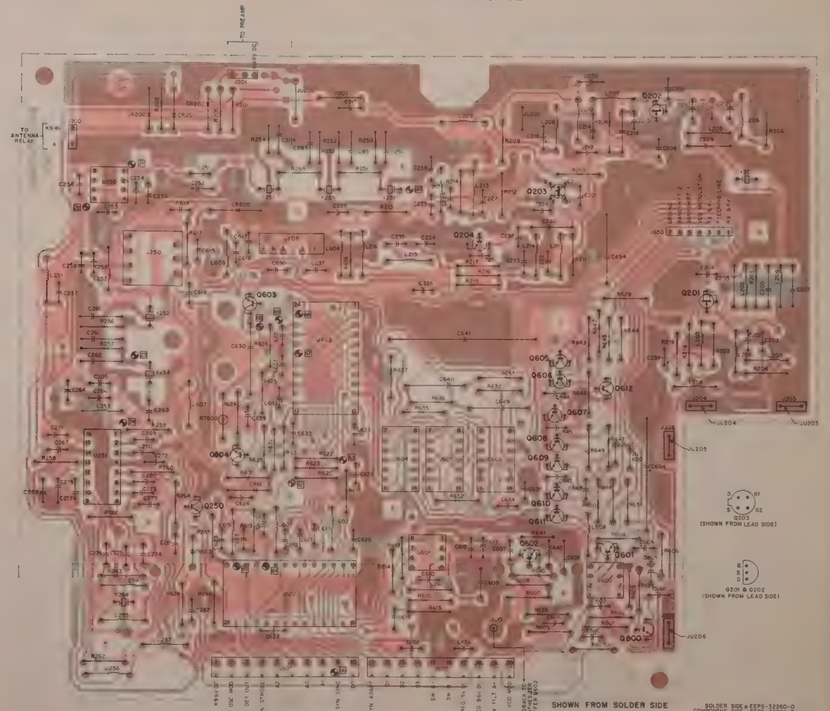
## HLD4108A FIRST MIXER


TO 5-POLE PRESELECTOR OUTPUT (L118)
TO INJECTION FILTER OUTPUT (L120)
TRANSISTOR DETAIL FROM WIRE LEAD SIDE
SHOWN FROM COMPONENT SIDE

## HLN4250A LOW PASS FILTER




## HLN4239A RF BOARD




# RF BOARD, FIRST MIXER, AND LOW PASS FILTER CIRCUIT BOARD DETAILS AND PARTS LISTS

## parts list

HLN4239A RF Board (Receiver Station) PL-7618-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **capacitor, fixed: pF ± 5%; 100 V; unless otherwise stated:** |
| C202 | 21-11014H30 | 18 |
| C203, 204 | 21-11015B15 | .0015 uF ± 10% |
| C205, 208 | 21-82450B13 | 1.5; 500 V |
| C207 | 21-82450B08 | 1.2; 500 V |
| C209 | 21-82450B47 | 1; 500 V |
| C210 | 21-11014N14 | 6.8 ± 0.25% |
| C211 | 21-11014H48 | 91 |
| C212 | 21-11015B15 | .0015 uF ± 10% |
| C214 | 21-11015A07 | .01 uF + 80-20% |
| C215 | 21-11014H20 | 8.2 ± 0.25% |
| C216 | 21-82450B08 | 1.2; 500 V |
| C217 | 21-11015A07 | .01 uF + 80-20% |
| C218 | 23-11013D55 | 4.7 uF ± 20%; 20 V |
| C219 | 21-11014N18 | 5.1 ± 0.5% |
| C220 | 21-11015A07 | .01 uF + 80-20% |
| C221 | 21-11014H19 | 5.6 ± 0.5% |
| C222 | 21-11015A07 | .01 uF + 80-20% |
| C223 | 21-11014H18 | 4.3 ± 0.25% |
| C224 | 21-11015A07 | .01 uF + 80-20% |
| C225 | 21-11014H08 | 2.0 ± 0.25% |
| C226 | 21-11015A07 | .01 uF + 80-20% |
| C227 | 21-11014H31 | 18 |
| C228 | 21-11015A07 | .01 uF + 80-20% |
| C229 | 21-11014N14 | 6.8 ± 0.25% |
| C230 | 52-82450B08 | 1.2; 500 V |
| C231 | 21-11014H19 | 5.6 ± 0.5% |
| C232 | 21-11014H38 | 30 |
| C233 | 21-11015A07 | .01 uF + 80-20% |
| C234 | 21-11015B03 | 150 ± 10% |
| C235 | 21-11014H28 | 13 |
| C236 | 21-11015B15 | .0015 uF ± 10% |
| C237 | 21-11015B05 | 220 ± 10% |
| C238 | 21-11014H15 | 3.9 ± 0.25% |
| C239 | 23-84536D06 | 47 uF ± 20%; 20 V |
| C240 | 21-11015B05 | 220 ± 10% |
| C250 | 21-82450B47 | 1.0; 500 V |
| C251 | 21-11014H38 | 30 |
| C252 | 21-11014E35 | 27 |
| C253, 254, 255 | 21-11014A07 | .01 uF + 80-20% |
| C256 | 21-84637L37 | 0.1 uF ± 10% 50 V |
| C257 | 21-11015A07 | .01 uF + 80-20% |
| C258 | 21-11014H36 | 30 |
| C259 | 21-11014H39 | 39 |
| C260,261 | 21-82450B47 | 1.0, 500 V |
| C262 | 21-82450B06 | 1.2; 500 V |
| C263 | 21-11014H13 | 3.3 ± 0.25% |
| C264 | 21-11014H33 | 22 |
| C265 | 21-11014H35 | 27 |
| C266 | 21-11014H39 | 39 |
| C267 thru 273 | 21-11015A07 | .01 uF + 80-20% |
| C274 | 21-11014H40 | 43 |
| C275 | 21-11014H30 | 18 |
| C276 | 21-11014H20 | 8.2 ± 0.5% |
| C277 | 21-11015A07 | 7.01 uF + 80-20% |
| C278 | 21-84637L37 | 0.1 uF ± 10%; 50 V |
| C279 | 21-11015A07 | .01 uF + 80-20% |
| C280, 281 | 21-11015B09 | 470 ± 10% |
| C282 | 21-11015A07 | .01 uF + 80-20% |
| C223 | 21-82450B47 | 1.0; 500 V |
| C224, 225 | 21-82450B47 | 1.0; 500 V |
| | | **diode: (see notes)** |
| CR200, 203 | 48-83654H01 | silicon |
| | | **connector, receptacle:** |
| J200 | 28-84324M01 | male 2-contact |
| J201 | 28-84324M02 | male 3-contact |
| J202 thru 206 | 42-83691L01 | female single contact |
| J250 | 9-84207B01 | female 7-contact |
| | | **coil, rf: uH** |
| L200 | 24-83397L13 | choke 0.82 |
| L201 202 | 24-83397L12 | choke 10 |
| L203 | 24-82723H07 | choke 10 |
| L204 | 24-83397L12 | choke 1.2 |
| L205 | 24-83397L13 | choke 0.82 |
| L206 | 24-82723H13 | choke 0.85 |
| L207 | 24-83397L13 | choke 0.82 |
| L208, 209 | 24-82723H07 | choke 10 |
| L210 | 24-83397L13 | choke 0.82 |
| L211 | 24-83397L12 | choke 1.2 |
| L212 | 24-8396OB01 | ferrite bead |
| L213 | 24-82835G41 | choke 5.6 |
| L214 | 24-82723H05 | choke 0.410 |
| L215, 216 | 24-83397L07 | choke 10 |
| L217 | 24-83397L08 | choke 15 |
| L250, 251, 252 | 24-83397L07 | choke 10 |
| L253, 254, 255 | 24-83397L08 | choke 15 |
| L256, 257 | 24-82723H07 | choke 10 |
| L258 | 24-83397L12 | choke 1.2 |

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **transistor (see notes)** |
| C200 | 48-869643 | PNP, type M9643 |
| C201, 202 | 48-869839 | N channel FET, type M9839 |
| Q203 | 48-844712,12 | Dual Gate MOS FET, type M1212 |
| 204 | 48-869932 | NPN, type M9932 |
| 250 | 48-869643 | PNP, type M9643 |
| | | **resistor, fixed: ± 5%; 1/4 W unless otherwise stated** |
| R203 | 6-11009C01 | 10 |
| R204 | 6-11009C27 | 120 |
| R205 | 6-11009C59 | 2.7k |
| R206 | 6-11009C27 | 120 |
| R207 | 6-11009C01 | 10 |
| R208 | 6-11009C65 | 4.7k |
| R209 | 6-11009C59 | 2.7k |
| R210 | 6-11009C69 | 6.8k |
| R211 | 6-11009C75 | 12k |
| R212 | 6-11009C35 | 270 |
| R213 | 6-11009C93 | 68k |
| R214 | 6-11009C57 | 2.2k |
| R215 | 6-11009C49 | 1k |
| R216 | 6-11009C65 | 4.7k |
| R217 | 6-11009C41 | 420 |
| R218 | 6-11009C01 | 10 |
| R219 | 6-11009C63 | 3.9k |
| R250 | 6-11009C85 | 33k |
| R251 | 6-11009C45 | 680 |
| R252, 253, 254 | 6-11009C85 | 33k |
| R255 | 6-11009C49 | 1k |
| R256, 257 | 6-11009C81 | 22k |
| R258 | 6-11009C99 | 120k |
| R259 | 6-11009C41 | 470 |
| R260 | 6-11009C89 | 47k |
| R261 | 6-11009C73 | 10k |
| R262 | 6-11009C86 | 220k |
| R263 | 6-11009C73 | 10k |
| R264 | 6-11009C49 | 1k |
| R265 | 6-11009C79 | 18k |
| R266 | 6-11009C49 | 1k |
| R269 | 6-11009C45 | 680 |
| | | **integrated circuit (see notes)** |
| U250 | 51-8006C02 | r-f amplifier, type M9602 |
| U251 | 51-8006903 | quad detector, type M9903 |
| | | **crystal** |
| Y200 | 48-83742M01 | filter, 53.9 MHz |
| Y250 | 48-84396K05 | resonator 10.7 MHz |
| Y251 | 48-84396K01 | resonator 10.7 MHz |
| Y252, 253, 254 | 48-84396K02 | resonator 10.7 MHz |
| Y255 | 48-84574K01 | resonator 10.7 MHz |
| | | **mechanical parts** |
| | 75-05295B01 | PAD, xtal |
| | 26-84978M01 | SHIELD, 2 used |
| | 55-84300B05 | HANDLE, 2 used |
| | 14-84602K01 | INSULATOR, 2 used |

notes:
1. For optimum performance, diodes, transistors and integrated circuits must be ordered by Motorola part numbers.
2. For parts not listed in the above parts list, refer to the mechanical parts section.

HLN4250A Low Pass Filter PL-7615-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **capacitor, fixed: pF ± 5%, 100 V:** |
| C110 | 21-11014N35 | 27 |
| C111 | 21-11014H48 | 91 |
| C112 | 21-11014H30 | 18 |
| C113, 114 | 21-11014H36 | 30 |
| C115 | 21-11014H30 | 18 |
| C116 | 21-11014N35 | 27 |
| | | **coil, rf:** |
| L110, 112, 113 | 24-83884G09 | choke, 6-1/2 turns coded ORG |
| | | **resistor, fixed:** |
| R110 | 6-11009C73 | 10k ± 5%, 1/4 W |
| | | **mechanical part** |
| | 26-84918M01 | SHIELD, filter |

HLN4260A Internal Casting Hardware Kit PL 7614-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **capacitor, fixed:** |
| C100 | 21-861219 | 1000 pF + 100-0%, 500 V |
| C160 | 21-828051404 | 28 pF ± 10%, 200 V |
| | | **connector, receptacle:** |
| J100, 101 | 9-84135B02 | female, single contact |
| | | **coil, rf:** |
| L114 | 24-84832M01 | coded RED |
| L115 116, 117 | 24-84832M02 | coded ORG |
| L118 | 24-84832M06 | coded WHT |
| L119 | 24-84832M04 | coded YEL |
| L120 | 24-84832M05 | coded GRN |
| L121 | 24-84832M04 | coded YEL |
| | | **mechanical part** |
| | 15-84776M01 | cover |

HLD4108A First Mixer PL-7613-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **capacitor, fixed: pF ± 5%; 100 V; unless otherwise stated** |
| C151, 152 | 21-11015B03 | 150 ± 10% |
| C153 | 21-11014H32 | 20 |
| C154 | 21-11014H41 | 47 |
| C156 | 21-11014H16 | 4.3 ± 0.25% |
| 157 | 21-11015B15 | 1500 ± 10% |
| C158 | 21-11014H48 | 91 |
| C159 | 21-11014H41 | 47 |
| | | **coil, rf: uH** |
| L150 | 24-82723H05 | choke 0.41 |
| L152 153 | 24-83397L13 | choke 0.82 |
| L154 | 24-82723H22 | choke 0.15 |
| | | **transistor: (see notes) field effect, type M2201** |
| Q150, 151 | 48-82022N01 | |
| | | **resistor, fixed:** |
| R150, 151 | 6-11009C33 | 220 ± 5%, 1/4 W |
| | | **transformer:** |
| T150, 151 | 24C80276D01 | toroid |

note
1. For optimum performance, diodes, transistors, and integrated circuits must be ordered by Motorola part number.
2. Transistors Q150 and Q151 must be replaced as a pair.

*Receiver Schematic Diagram, Circuit Board Detail, and Parts Lists*
*Motorola No. PEPS-32268-O*
*(Sheet 2 of 2)*
*10-2-81 NPC*

RECEIVER

## 1. THEORY OF OPERATION

### 1.1 INTRODUCTION

The *SYNTOR X* high-band transmitter comprises three major sections: the intermediate power ampifiers (IPA), the power amplifier (PA), and the directional coupler board. All transmitter sections have 50-ohm interfaces that facilitate troubleshooting and repair.

### 1.2 IPA

The 40 mW fm transmit injection signal from the frequency synthesizer is applied to the two-stage variable gain exciter. Collector current for these stages (Q701 and Q702) is proportional to the power control voltage developed by the regulating and protective feedback system . The output of the IPA (1.5 W maximum) is coupled to the power amplifier.

### 1.3 POWER AMPLIFIER

The rf signal passes from the IPA board to the final power amplifier via a coaxial cable and is then applied to the predriver stage (Q801), which is followed by the driver stage (Q802). The final output level (75 W/ 110 W) is provided by two Class C, parallel transistor stages (Q803 and Q804). Temperature and current sensing circuits located near the final stages, in conjunction with the power control loop, protect the final power devices against excessive thermal and current stresses.

### 1.4 DIRECTIONAL COUPLER BOARD

The rf power output from the final amplifier board is applied to a directional coupler. The directional coupler is used to measure both the forward and reflected power. Information related to the forward and reflected power is relayed to the rf power control circuit, located on the common circuits board. The directional coupler rf output is routed to the antenna via the antenna switch and a coaxial cable.

### 1.5 METERING

The transmitter metering socket (J952), located on the common circuits board, allows monitoring of the following transmitter parameters:

- J952-3 permits checking the IPA control voltage
- J952-4 provides a dc voltage proportional to the 9.6 V regulated supply
- J952-5 is used to measure the transmitter final stages current.

### 1.6 POWER CONTROL AND PROTECTION CIRCUITRY

1.6.1 Sensing circuits monitor PA current, heatsink temperature, control voltage, forward power, and reflected power. These parameters are compared to acceptable references and combined to form the control voltage which regulates and protects the PA by controlling the variable gain exciter stages.

1.6.2 During normal operation, transmitter output power is regulated as a function of the detected forward power level. The directional coupler board contains a pick-up element and signal diodes which provide output voltage proportional to the forward and reflected power levels. The detected forward power voltage is applied to U901A which compares its level to the adjustable reference established by POWER SET potentiometer R911. The output of the comparator is amplified by Q903 and Q904 to provide the power control voltage to the exciter.

1.6.3 Transmitter protection is assured by monitoring and limiting critical PA parameters. Final stage PA current passes through R801 causing a proportional current path from current limiter circuit Q906-Q908. If the current drawn overcomes an adjustable level, established by CURRENT LIMIT potentiometer R939, then Q9067 conducts harder, increasing the quiescent level applied to protection comparator U901B. Similarly, a voltage proportional to the VSWR at the directional coupler board is added to the steady state level at

the input of the protection comparator. An increased input level causes a decreased U901B output, increasing the conduction of Q905 which is applied to the forward power level comparator circuitry. This causes the control voltage to decrease which ultimately reduces the PA power level.

1.6.4 The control voltage is monitored by applying a portion of the signal to the emitter of Q905 and comparing it to the base which is biased by the protection comparator output. An increase of the control voltage causes feedback to the comparators to lower the control voltage level.

## 2. TRANSMITTER FUNCTIONAL TESTS

**NOTE**

Refer to the Synthesizer section in the manual for information on transmit frequency, audio deviation, and modulation troubleshooting.

### 2.1 PRELIMINARY

Connect the radio to a proper wattmeter, dummy load, and 13.4 V dc supply. Plug in either a TEK5 series meter panel set to position C or a portable test set to alignment metering jack J952. Use the neutral or receive position for the meter panel or set the function switch to the receive position if the portable test set is used.

**CAUTION**

Key the transmitter only while making adjustments or observing meters. (All adjustments are made from the bottom of the radio and through the common circuits board.)

### 2.2 CONTROL AND PROTECTION TESTS

#### 2.2.1 Current Limiting (R939)

Step 1. Set POWER SET (R911) fully clockwise.

Step 2. Set CURRENT LIMIT (R939) fully counterclockwise.

Step 3. Key transmitter and observe meter 5. Meter 5 should indicate less than 5 uA. Rotate CURRENT LIMIT (R939) counterclockwise. Meter 5 should increase to a maximum reading of less than 30 uA before the maximum counterclockwise position is reached.

#### 2.2.2 Power Set (R911)

Step 1. Set CURRENT LIMIT (R939) and CONTROL VOLTAGE LIMIT SET (R931) fully clockwise.

Step 2. Set POWER SET (R911) fully counterclockwise.

Step 3. Key transmitter and observe wattmeter. Power output should be 0 watts. Power output should increase as POWER SET (R911) is rotated clockwise.

#### 2.2.3 Thermal Protection

Step 1. Set CURRENT LIMIT (R939) fully counterclockwise.

Step 2. Adjust POWER SET (R911) to the proper power set level for the radio being tested. Using an insulated jumper clip, short the TEMP SENSE lead to the B− lead (black wire connected to C883 and C882, respectively, on the PA feedthrough plate). Key transmitter. Power output should be less than 25% of set power.

#### 2.2.4 Reflected Power (VSWR) Protection

Step 1. Set CURRENT LIMIT (R939) fully counterclockwise.

Step 2. Key the transmitter and adjust POWER SET (R911) for normal power setting.

**CAUTION**

Since the following test requires transmission without a dummy load, the transmitter should be keyed only long enough to allow verification of proper operation of the equipment.

Step 3. Remove the 50-ohm load from the radio. Briefly key the transmitter and verify that an output power indication of less than 50% is obtained.

### 2.3 RF AMPLIFICATION TESTS

#### 2.3.1 Injection

Step 1. Disconnect rf drive signal to exciter from synthesizer (J700).

Step 2. Connect a 50-ohm-terminated rf millivoltmeter to the synthesizer's transmitter injection plug (P700). Residual rf drive to the exciter in the receive mode should be less than −15 dBm. Transmitter injection in the transmit mode should be greater than +16 dBm.

#### 2.3.2 Exciter

Step 1. Disconnect exciter output cable from PA and connect to a wattmeter and dummy load.

Step 2. Set POWER SET (R911) and CURRENT LIMIT (R939) to mid rotation.

*Table 1. Minimum Normal Current Indications (With All Power Control Potentiometers Set Fully Clockwise)*

| Power Output | Transistor | Ic | 136-144 MHz | 150-155 MHz | 155-162 MHz | 162-174 MHz |
|---|---|---|---|---|---|---|
| 75 W/110 W | Q801 | Direct | — | 1.7A | 1.2A | 0.75A |
| | Q802 | Direct | — | 2.4A | 2.4A | 2.5A |
| | Q802 | Drop across R822 | — | 240 mV | 240 mV | 250 mV |
| | Q803-4 | Drop across R801 | — | 160 mV | 170 mV | 1610 mV |
| | Q803-4 | MTR 5 | — | 16 uA | 17 uA | 16 uA |

**NOTE**

Direct current measurements are taken by inserting an ammeter into dc feed circuit from the common A + connection.

Step 3. Key transmitter. Minimum output power should exceed 1.5 watts.

2.3.3 Power Amplifier

Step 1. Disconnect PA from antenna switch at J901 located on the Directional Coupler board.

Step 2. Connect PA to wattmeter and dummy load via J901.

Step 3. Set POWER SET (R911) fully clockwise and CURRENT LIMIT (R939) fully counterclockwise. Key transmitter. Output power should exceed rated radio power by at least 20%.

## 3. POWER AMPLIFIER TROUBLESHOOTING GUIDE

### 3.1 INTRODUCTION

This guide can be used to locate faults isolated to the *SYNTOR X* high-band power amplifier. The following checks assume that 13.5 V dc is applied to the radio set thorugh a standard cable kit and that the power control potentiometer R911 is set fully clockwise and the current limit potentiometer R939 is set fully counterclockwise, with the radio keyed on a defective channel — unless otherwise stated.

### 3.2 NO POWER OUTPUT OR POWER OUTPUT LESS THAN 20% OF RATED POWER

3.2.1 Voltage Checks

With the radio unkeyed and the receiver audio at a minimum, check for +13.3 V dc on the collectors. If one or more stages have zero voltage, check associated dc feed circuits for an open circuit.

3.2.2 Individual Stage Current Checks

Check the collector currents drawn by all stages to determine if the normal value shown in Table 1 is drawn.

Step 1. If a stage is found with less than minimum $I_c$ (see Table 1), check for shorts or defective components in that stage, then in the preceding and following stages.

Step 2. Where more than one stage indicates low current, check the earliest defective stage (toward the PA input) first.

Step 3. If all stages give a low current indication, check the exciter output. The exciter is defective if the output is less than 1.5 W.

### 3.3 POWER OUTPUT DOES NOT EXCEED THE RATED RADIO POWER BY 20% AT MAXIMUM POWER SETTINGS

3.3.1 Check A+ and A− voltages at the collectors with the power amplifier operating. Use ***only*** a passive voltmeter or a VOM with 1.2 uH series chokes at the probe tips. With the power supply accurately set for 13.5 V dc, voltages on the transistor collectors should exceed the Table 2 values (all voltages measured with respect to the A− plating on the power amplifier board).

Step 1. If all voltages are low, recheck the power supply. If the power supply is satisfactory, check the feedthrough capacitors for poor solder connections and the front plug A+ and A− connections for good contact.

Step 2. If only one or two stages have low voltages, trace back through the dc-feeds of that stage, checking for bad connections or defective components. The maximum normal voltage drops are 0.3 V dc for R801, 0.5 V dc for R822, and less than 0.1 V dc for all other components in the dc-feed circuits.

3.3.2 Check the stage currents as outlined in paragraph 3.2.2.

*Table 2. PA Collector Voltages*

| Transistor | 75/110 W HLD4076A |
|---|---|
| Q801 | 12.0 V dc |
| Q802 | 11.8 V dc |
| Q803-4 | 11.8 V dc |

3.3.3 If trouble in the finals (Q803, Q804) is indicated, or other approaches have failed, check the balance in the final amplifier by soldering a 2.7 V lamp (type 338, Motorola Part No. 65-82671G01) across R819 using #14 wire or a 0.1 inch wide copper strap or braid. If the lamp lights up to greater than half its normal brilliance, or flashes and burns out, there is a defect

in one side of the parallel final amplifier circuitry. If such imbalance is indicated, the defective section can usually be isolated by shorting the base to emitter of one transistor (at the transistor body, opposite C825 or C826) with a screwdriver blade. The section that shows the *least* drop in power output (when shorted) is the one to be checked for defective components. If no obviously defective passive components, bad connections, or shorts can be located, make the following tests prior to considering the replacement of Q803 or Q804.

**CAUTION**

Remove all power from the radio set for the following tests.

**NOTE**

Place the negative potential lead from the ohmmeter on the transistor base for this test.

Step 1. Check in-circuit base-emitter resistance on the suspect transistor(s). If *greater* than 1 ohm, coil L809 or L810 is bad.

Step 2. If the resistance check shows that L809 and L810 are not defective, remove capacitor C825 or C826 and check it for shorts, both internal (with an ohmmeter), and external (visual check for solder shorts on the capacitor or printed circuit board). If the capacitor or its connection is suspect, replace it and recheck the power output and balance before proceeding.

Step 3. If the capacitor is not defective, replace transistor Q803 or Q804 and reassemble the power amplifier.

**NOTE**

In any case where gross imbalance is found and suspected faulty components are replaced, ***always*** recheck balance after replacing components. Continue the investigation if imbalance has not been fully corrected.

**NOTE**

Place negative potential lead of ohmmeter on transistor base(s) for following test.

3.3.4 With all power removed from the radio set, check for open base return on Q801 and Q802 by measuring in-circuit base-emitter resistance. The resistance should be less than 1 ohm on Q801 and less than 2.5 ohms on Q802.

*Table 3. Transmitter Troubleshooting Chart*

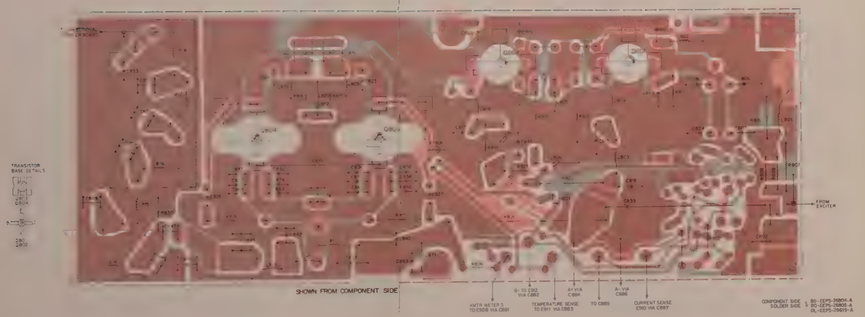
| Step | Symptom | Procedure | Normal Indication | If Normal | If Abnormal |
|---|---|---|---|---|---|
| 1 | Suspected Transmitter Failure | Measure rf output power at antenna connector. | Rated power | Transmitter OK. | High Power — perform Transmitter Control and Protection Troubleshooting Procedure.<br>Low Power—go to Step 3.<br>No Power—go to Step 2. |
| 2 | No Output Power | **a.** Set POWER SET control fully clockwise and CURRENT LIMIT fully counterclockwise and observe meter 3 and 5. | Both greater than 10 uA | Go to b. | No indication — Perform Transmitter Control and Protection Troubleshooting Procedure.<br>Meter 3 indication, no Meter 5 indication—Go to Step 2e. |
| | | **b.** Measure DC voltage across antenna relay coil during Tx. | 4.5 V dc | Go to Step 3c. | Check coil continuity (DC resistance approx. 160 ohms). |
| | | **c.** Check reed switch continuity. | Continuous during Tx | Go to Step 3d. | Replace switch. |
| | | **d.** Check Harmonic Filter and output cable for shorts and discontinuities. | See schematic diagram | Perform Power Amplifier Troubleshooting Procedure. | Repair defect. |
| | | **e.** Measure rf signal level at synthesizer output J1151. | +16 dBm minimum | Go to Step 3f. | Perform Synthesizer Troubleshooting Procedure. |
| | | **f.** Measure rf power at the exciter output. | 1.5 W minimum | Perform Power Amplifier Troubleshooting Procedure. | Repair Exciter. |
| 3 | Low Output Power | **a.** Set POWER SET control fully clockwise and CURRENT LIMIT fully counterclockwise and observe meter 3. | Greater than 20 uA | Go to Step 3b. | Perform Transmitter Control and Protection Troubleshooting Procedure. |
| | | **b.** Measure rf power at synthesizer output J1151. | +16 dBm minimum | Go to Step 3c. | Perform Synthesizer Troubleshooting Procedure. |
| | | **c.** Measure rf power at exciter output. | 1.5 W minimum | Perform Power Amplifier Troubleshooting Procedure. | Repair Exciter. |

*Table 4. Transmitter Control and Protection Circuitry, Troubleshooting Chart*

| Step | Symptom | Procedure | Normal Indication | If Normal | If Abnormal |
|---|---|---|---|---|---|
| 1 | No meter 3 or 5 with all controls open (POWER SET clockwise and CURRENT LIMIT counterclockwise). | **a.** Disconnect exciter from synthesizer at J1151. Check for keyed 9.5 V dc @ pin 8, U901. | 9.5 V dc | Go to Step 1b. | **a.** Check PA ENABLE @ P401-10. **b.** Check for synthesizer lock. **c.** Check Q1007 (TX 9.5 V switch). **d.** Check PA ENABLE switch (Q5 and Q6). |
| | | **b.** Measure output voltage of U901A, pin 1. | > 3.3 V dc | Repair fault in control voltage amplifiers Q903 & Q904. | Go to Step 1c. |
| | | **c.** Measure voltages to input of U901A, pins 2 & 3. | Pin 3 > Pin 2 | U901 defective. | Check for shorts or opens in resistive feed circuits to pins 2 & 3. |
| 2 | Meter 3 reads max of about 10 uA with all controls fully open. Little or no output power. | **a.** Disconnect exciter from synthesizer at J1151. Measure voltage of protection comparator output, pin 7 U901B. | > 8 V dc | Troubleshoot Q905 circuit | Go to Step 2b. |
| | | **b.** Measure voltages to input of U901B, pins 5 & 6. | Pin 5 > Pin 6 | U901 defective | Analyze and repair current limiter circuitry Q906, Q907 & Q908. |
| 3 | All controls inoperative and meter 3 25 uA. | **a.** Disconnect exciter from synthesizer at J101. Observe meter 3 in RX mode. | 0 uA | Go to Step 3b. | Repair fault in control voltage amplifiers Q903 & Q904. |
| | | **b.** Set all controls counterclockwise. Measure pins 2 & 3, U901A in TX mode. | Pin 2 > Pin 3 | U901 defective | Look for defect in voltage reference network R926, R927, R928, R921, R911. |
| 4 | Control voltage limit (R931), current limit (R939) and reflected power (VSWR) protection inoperative. | Q905 and associated resistors probably open. Analyze and repair. | | | |
| 5 | Current limit (R939) inoperative. | Disconnect exciter from synthesizer at J700. Unsolder CURRENT SENSE line (GRN) from C887. Observe meter 3. | 15 uA | Check for short to A + of current sense line. | Analyze fault in current limit circuit Q906, Q907 & Q908 and repair. |
| 6 | Reflected power (VSWR) protection inoperative. | Check and repair defect in reflected power detector components R901, CR901, etc. | | | |
| 7 | Thermal protection inoperative. | Check and repair defect in thermal protection components R915, R930 and CR904. | | | |
| 8 | Power set (R911) inoperative. | Check and repair defect in forward power detector components R902, CR902, etc. | | | |

# POWER AMPLIFIER

75/110 WATT, 150-174 MHz
MODEL HLD4076A




*HLD4076A Power Amplifier, HLN4247A IPA, and HLN4242A Directional Coupler Schematic Diagrams, Circuit Board Detail, and Parts Lists*
*Motorola No. PEPS-32919-O*
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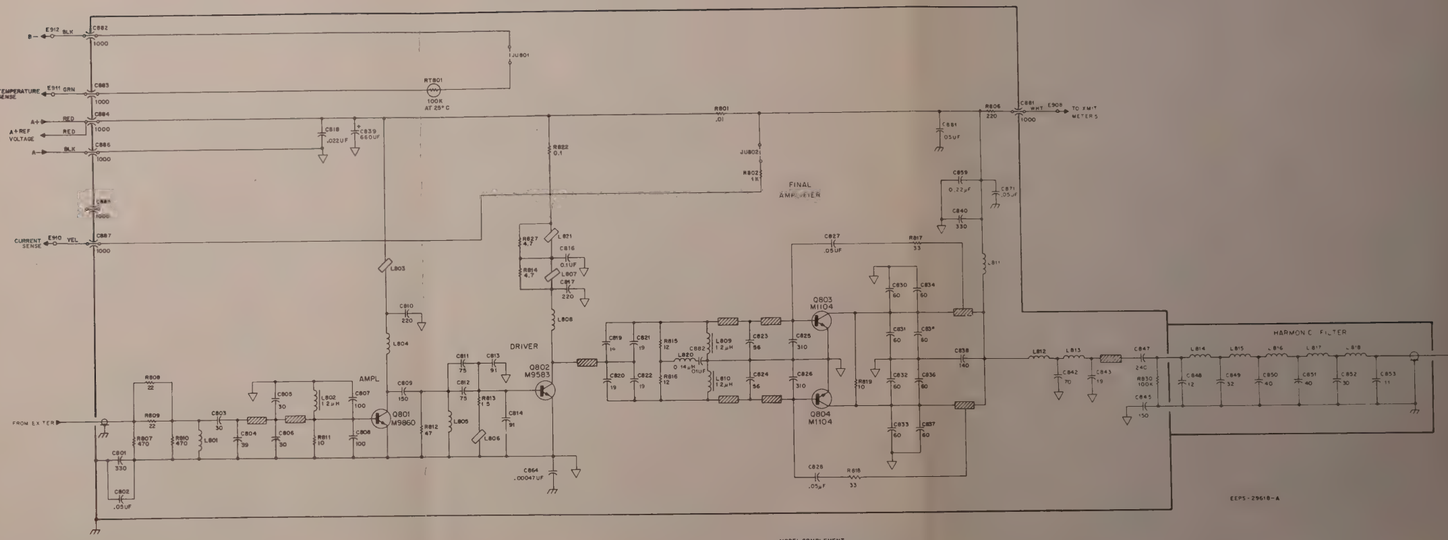
*10 2-81-SPC*



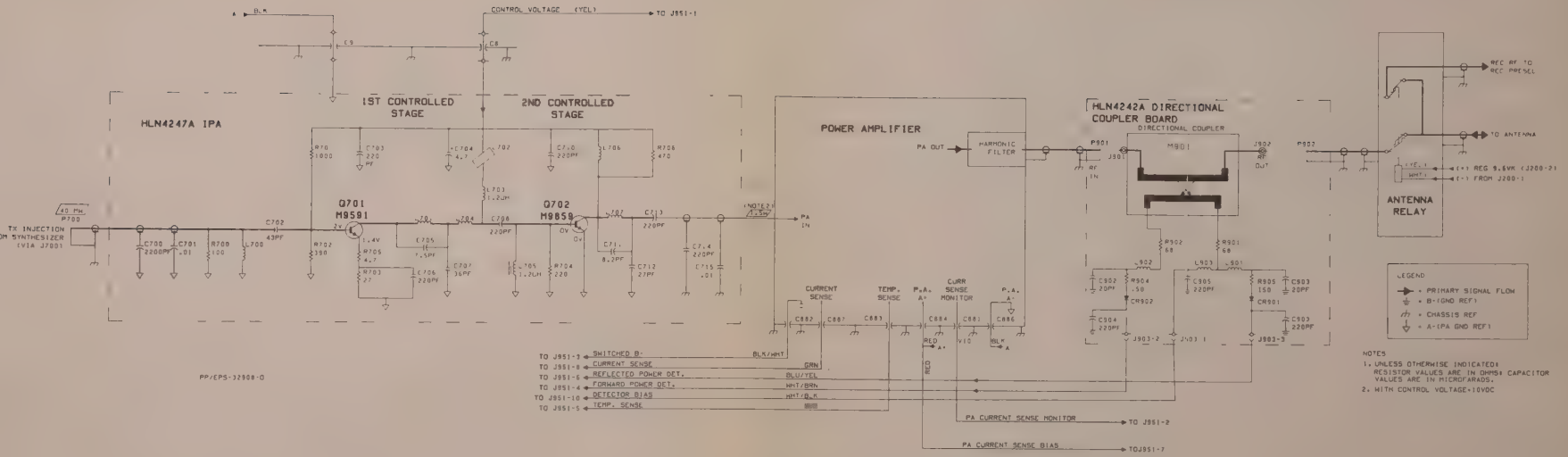

NOTES:
1. UNLESS OTHERWISE SPECIFIED, CAPACITOR VALUES ARE IN PICOFARADS
2. INDICATES MICROSTRIP TRANSMISSION LINE.
3. INDICATES PA REF (A+)
   INDICATES CHASSIS REF
4. ALL PARTS MAY BE REMOVED FROM THE TOP OF THE BOARD

CAUTION
When MOUNTING TRANSISTORS DO NOT OVERTIGHTEN (BEYOND 5-7 INCH POUNDS) OR DAMAGE TO TRANSISTORS MAY RESULT.

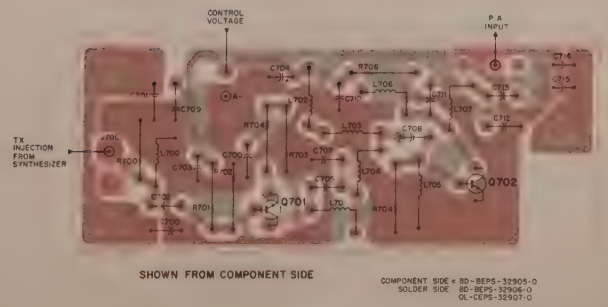
MODEL COMPLEMENT
HLN4084A HARDWARE KIT (RG3E-RG7E)
HLD4076A PA BOARD (R3E-R3E)
HLD4267A POWER TRANSISTOR (RG3E-RG7E)
HLN4046A FEED THRU PLATE

# HLN4247A IPA AND HLN4242A DIRECTIONAL COUPLER

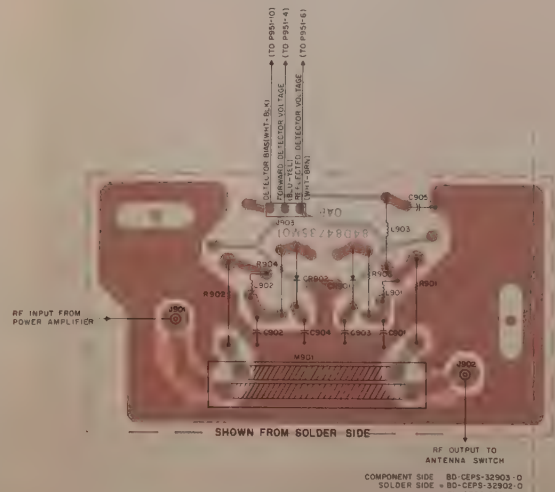
## SCHEMATIC DIAGRAM AND CIRCUIT BOARDS




### HLN4247A IPA




### HLN4242A DIRECTIONAL COUPLER




*HLD4076A Power Amplifier, HLN4247A IPA, and HLN4242A Directional Coupler Schematic Diagrams, Circuit Board Detail, and Parts Lists*
*Motorola No. **PEPS-32919-O***
*(Sheet 2 of 3)*
*10/2/81-NPC*

# PARTS LISTS

HLD4076A Power Amplifier Board — PL-6859-A

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **capacitor, fixed: pF ± 5%, 500 V:** unless otherwise stated |
| C801 | 21-863629 | 330 ± 10% |
| C802 | 21-82372C10 | .05 ± 20%; 25 V |
| C803 | 21-83406D77 | 30 |
| C804 | 21-84493B59 | 39 |
| C805, 806 | 21-83406D77 | 30 |
| C807, 808 | 21-84493B65 | 100 |
| C809 | 21-84493B66 | 150 |
| C810 | 21-83596E10 | 220 ± 20%; 200 V |
| C811, 812 | 21-84493B63 | 75 |
| C813, 814 | 21-84493B64 | 91 |
| C816 | 8-82096J18 | 0.1 uF ± 10%; 250 V |
| C817 | 21-83596E10 | 220 ± 20% |
| C818 | 8-82096J08 | .022 uF ± 10%; 250 V |
| C819 thru 822 | 21-84493B35 | 19 |
| C823, 824 | 21-84715F26 | 56 |
| C827, 828 | 21-82372C10 | .05 uF ± 20%; 25 V |
| C830 thru 837 | 21-80169A74 | 60 |
| C838 | 21-84395B47 | 140; 350 V |
| C839 | 23-83210A22 | 660 uF + 150-10%; 25 V |
| C840 | 21-863629 | 330 ± 10%; 5 V |
| C841 | 21-84366F12 | 0.1 uF ± 10%; 250 V |
| C842 | 21-84395B40 | 70; 350 V |
| C843 | 21-84395B41 | 19; 350 V |
| C845 | 21-84395B46 | 150, 250 V |
| C847 | 21-84395B35 | 240 ± 10%; 350 V |
| C848 | 21-84395B45 | 12; 350 V |
| C849 | 21-84395B28 | 32 |
| C850, 851 | 21-84395B36 | 40; 350 V |
| C852 | 21-84395B39 | 30; 350 V |
| C853 | 21-84395B38 | 11; 350 V |
| C859 | 8-82096J20 | 0.22 uF ± 10%; 250 V |
| C864 | 21-82187B07 | .00047 uF ± 10% |
| C865 | 21-83596E10 | 220 ± 20% |
| C871 | 21-82372C04 | .05 uF + 80-20%; 25 V |
| C872 | 21-83596E21 | .01 uF + 80-20%; 200 V |
| C881 | 21-82372C04 | .05 uF + 80-20%; 25 V |
| C882 | 21-83596E21 | .01 uF + 80-20%; 200 V |
| | | **coil, rf:** |
| L801 | 24-83884G01 | 3-1/2 turns |
| L802 | 24-82723H27 | 1.2 uH |
| L803 | 24-80036A02 | ferrite bead, 1/2 turn |
| L804 | 24-80277A01 | 12-1/2 turns |
| L805 | 7-80062B02 | 1/2 turn |
| L806, 807 | 24-80036A02 | ferrite bead, 1/2 turn |
| L808 | 24-80277A05 | 1-1/2 turns |
| L809, 810 | 24-82723H27 | 1.2 uH |
| L811 | 24-80277A04 | 7-1/2 turns |
| L812 | 7-80062B04 | 1/2 turn |
| L813 | 24-80277A08 | 1-1/2 turns |
| L814 | 24-80277A09 | 6-1/2 turns |
| L815 thru 818 | 24-80277A02 | 6-1/2 turns |
| L820 | 24-82723H24 | 140 nH |
| L821 | 24-80036A02 | ferrite bead, 1/2 turn |
| | | **resistor, fixed: ± 5%; 1/2 W:** unless otherwise stated |
| R801 | 17-80165C01 | .01; 10 W |
| R802 | 6-124A49 | 1k; 1/4 W |
| R806 | 6-124C33 | 220 ± 10%; 1/4 W |
| R807 | 6-125A41 | 470 |
| R808, 809 | 6-124A09 | 22; 1/4 W |
| R810 | 6-125A41 | 470 |
| R811 | 6-125C01 | 10 ± 10% |
| R812 | 6-127C17 | 47 ± 10%; 2 W |
| R813 | 17-82036G07 | 1.5 ± 10%; 2 W |
| R814 | 6-125B61 | 4.7 |
| R815, 816 | 6-125C03 | 12 ± 10% |
| R817, 818 | 17-82036G11 | 33 ± 10%; 2 W |
| R822 | 17-82291B24 | 0.1; 3 W |
| R827 | 6-125B61 | 4.7 |
| R830 | 6-124C97 | 100k ± 10%; 1/4 W |
| | | **thermistor:** |
| RT801 | 6-83600K09 | 100k @ 25° C |

HLN4048A PA Feed-Thru Plate — PL-7620-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **capacitor, feedthru:** |
| C881 thru 885, 887, 888 | 21-82812H03 | 1000 pF + 100-0%; 500 V |

HLN4245A PA Hardware Kit — PL-7632-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **capacitor, fixed:** |
| C825, 826 | 21-80069B01 | 310 |

**note:** For parts not listed in the above parts list refer to the mechanical parts section.

HLD4067A Power Transistor Kit — PL-6858-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **transistor: (see note)** |
| Q801 | 48-869860 | NPN, type M9860 |
| Q802 | 48-869583 | NPN; type M9583 |
| Q803,804 | 48-84411L04 | NPN; type M1104 |
| | | **resistor, fixed:** |
| R819 | 6-127C01 | 10 ± 10%, 2 W |

**note:** For optimum performance, diodes, transistors, and integrated circuits must be ordered by Motorola part numbers.

HLN4247A Intermediate Power Amplifier — PL-7629-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **capacitor, fixed: pF ± 20%; 500 V:** unless otherwise stated |
| C700 | 21-11015B05 | 220 |
| C701 | 21-11015A07 | .01 uF + 80-20%; 200 V |
| C702 | 21-11014H40 | 43 ± 5% |
| C703 | 21-11015B05 | 220 |
| C704 | 23-11013D55 | 4.7 uF; 20 V |
| C705 | 21-11014H22 | 7.5 ± .5 pF |
| C706 | 21-11015B05 | 220 |
| C707 | 21-11014H38 | 33 ± 5% |
| C708 | 21-11015B05 | 220 |
| C710 | 21-11015B05 | 220 |
| C711 | 21-11014H23 | 8.0 ± .25 pF |
| C712 | 21-11014H35 | 27 ± 5% |
| C713, 714 | 21-11015B05 | 220 |
| C715 | 21-11015A07 | .01 uF + 80-20%; 200 V |
| | | **connector, receptacle:** |
| J700 | 9-84231B03 | phono, female |
| | | **connector, plug:** |
| P700 | 9-84231B03 | female, 3-contact |
| | | **coil, rf:** |
| L700 | 24-83884G01 | 3-1/2 turns, coded red |
| L701 | 24-83884G08 | 5-1/2 turns, coded org |
| L702 | 24-80036A01 | 1/2 turn |
| L703 | 24-82723H01 | 1.2 uH |
| L704 | 24-83884G07 | 2-1/2 turns, coded grn |
| L705 | 24-83961B02 | 5 turns, coded grn |
| L706 | 24-83884G06 | 4-1/2 turns, coded wht |
| L707 | 24-83884G07 | 2-1/2 turns, coded grn |
| | | **transistor: (see note)** |
| Q701 | 48-869591 | NPN; type M9591 |
| Q702 | 48-869859 | NPN; type M9859 |
| | | **resistor, fixed: ± 5%; 1/4 W:** |
| R700 | 6-11009C25 | 100 |
| R701 | 6-11009C49 | 1k |
| R702 | 6-11009C39 | 390 |
| R703 | 6-11009C11 | 27 |
| R704 | 6-111009C33 | 220 |
| R705 | 6-124B61 | 4.7 |
| R706 | 6-11009C41 | 470 |

**note:** For parts not listed in the above parts list, refer to the mechanical parts section

HLN4244A IPA Feedthru Plate — PL-7627-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **capacitor, fixed:** |
| C8, 9 | 21-82812H01 | feedthru, 470 pF ± 10%; 500 V |

HLN4242A Directional Coupler Board — PL-7626-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **capacitor, fixed: pF; 500 V;** |
| C901, 902 | 21-11014H32 | 20 ± 5% |
| C903, 904, 905 | 21-11015B05 | 220 ± 20% |
| | | **diode: (see note)** |
| CR901, 902 | 48-84616A01 | hot carrier |
| | | **connector, receptacle:** |
| J901, 902 | 9-84231B03 | female, single contact |
| J903 | 28-84324M02 | male, 3-contact |
| | | **coil, rf:** |
| L901, 902 | 24-84393B04 | 7-1/2 turns |
| L903 | 24-82723H01 | 1.2 uH |
| | | **resistor, fixed:** |
| R901, 902 | 6-125A21 | 68 ± 5%; 1/2 W |
| R904, 905 | 6-11009C29 | 150 ± 5%; 1/4 W |

**note:** For optimum performance, diodes, transistors, and integrated circuits must be ordered by Motorola part numbers.

*HLD4076A Power Amplifier, HLN4247A IPA, and HLN4242A Directional Coupler Schematic Diagrams, Circuit Board Detail, and Parts Lists*
*Motorola No.* ***PEPS-32919-O***
*(Sheet 3 of 3)*
*10/2/81- NPC*

# 110 W/10 W TRANSMITTER (OPTIONAL)

## 1. THEORY OF OPERATION

### 1.1 INTRODUCTION

The *SYNTOR X* dual-power high-band transmitter comprises four major sections: intermediate power amplifier (IPA), power amplifier (PA), attenuator and attenuator switch, and directional coupler. All transmitter sections are provided with 50-ohm interfaces to facilitate troubleshooting and repair of the equipment.

### 1.2 IPA STAGES

The 40 mW fm transmit injection signal from the frequency synthesizer is applied to the two-stage variable gain exciter. Collector current for these stages (Q701 and Q702) is proportional to the power control voltage developed by the regulating and protective feedback system. The output of the exciter (1.5 W maximum) is coupled to the power amplifier.

### 1.3 POWER AMPLIFIER

The rf signal passes from the exciter board to the final power amplifier, via a coaxial cable, and is then applied to the predriver stage (Q801), which is followed by the driver stage (Q802). The final output level of 110 W/10 W is provided by two Class-C transistor stages (Q803 and Q804) connected in parallel. Temperature- and current-sensing devices located near the final power output stages, in conjunction with the power control loop, are used to protect the final power output devices against excessive thermal and current stresses.

### 1.4 ATTENUATOR AND ATTENUATOR SWITCH

The final power amplifier rf output is applied to an efficient and reliable reed switch that routes the rf power output to the harmonic filter — either directly (110 W mode) or via an attenuator (10 W mode). The attenuator, which consists of a 50-ohm lossy microstrip line that provides a nominal attenuation of 4.7 dB, is used to reduce the 30 W input into a final output of 10 W.

### 1.5 DIRECTIONAL COUPLER BOARD

The rf power output from the harmonic filter board is applied to a directional coupler. The directional coupler is used to measure both the forward and reflected power. Information related to the forward and reflected power is relayed to the power control circuitry located on the common circuits board. The directional coupler rf output is routed to the antenna via the antenna switch and a coaxial cable.

### 1.6 METERING

The transmitter metering socket (J952), located on the common circuits board, allows monitoring of the following transmitter parameters:

- J952-3 permits checking the exciter control voltages
- J952-4 provides a dc voltage proportional to the 9.4 V regulated supply
- J952-5 is used to measure the final current of the transmitter.

### 1.7 POWER CONTROL AND PROTECTION CIRCUITRY (PART OF COMMON CIRCUITS BOARD)

1.7.1 Sensing circuits monitor PA current, heatsink temperature, control voltage, forward power, and reflected power. These parameters are compared to acceptable references and combined to form the control voltage which regulates and protects the PA by controlling the variable gain exciter stages.

1.7.2 During normal operation, transmitter output power is regulated as a function of the detected forward power level. The directional coupler board contains a pick-up element and signal diodes which provide output voltages proportional to the forward and reflected power levels. The detected forward power voltage is applied to U901A which compares its level to the adjustable reference established by POWER SET potentiometer R911 (high power mode), or to a combined reference set by R911 and POWER SET poten-

tiometer R983 (low power mode). The output of the comparator is amplified by Q903 and Q904 to provide the power control voltage to the exciter.

1.7.3 Transmitter protection is assured by monitoring and limiting critical PA parameters. Final stage PA current passes through R801 causing a proportional current path from current limiter circuit Q906-Q908. If the current drawn overcomes an adjustable level, established by CURRENT LIMIT potentiometer R939, then Q907 conducts harder, increasing the quiescent level applied to protection comparator U901B. Similarly, a voltage proportional to the VSWR at the directional coupler board is added to the steady state level at the input of the protection comparator. An increased input level causes a decreased U901B output, increasing the conduction of Q905 which is applied to the forward power level comparator circuitry. This causes the control voltage to decrease which ultimately reduces the PA power level.

1.7.4 The control voltage is monitored by applying a portion of the signal to the emitter of Q905 and comparing it to the base which is biased by the protection comparator output. An increase of the control voltage causes feedback to the comparators to lower the control voltage level.

## 2. TRANSMITTER FUNCTIONAL TESTS

### 2.1 PRELIMINARY

Connect the radio to a proper wattmeter, dummy load, and 13.4 V dc supply. Plug in either a TEK5 series meter panel set to position C or a portable test set to alignment metering jack J952. Use the neutral or receive position for the meter panel or set the function switch to the receive position if the portable test set is used.

**CAUTION**

Select a channel programmed for high-power mode (110 W) except when stated to the contrary. Key the transmitter only when making adjustments or observing meters. (All adjustments are made from the bottom of the radio and through the common circuits board.)

### 2.2 CURRENT LIMITING (R939)

Step 1. Turn POWER SET potentiometer R911 fully clockwise.

Step 2. Turn CURRENT LIMIT potentiometer R939 fully clockwise.

Step 3. Key the transmitter and, observing Meter 5, verify that it is providing an indication of less than 5 uA. Rotate CURRENT LIMIT potentiometer R939 counterclockwise and verify that Meter 5 provides a maximum indication of less than 30 uA before the maximum counterclockwise position is reached.

### 2.3 POWER SET (R911), HIGH POWER OUTPUT MODE

Step 1. Set the CURRENT LIMIT potentiometer R939 fully counterclockwise.

Step 2. Set R911 (POWER SET potentiometer) fully counterclockwise.

Step 3. Key the transmitter and verify that a power output indication of zero is provided by the wattmeter. Slowly rotate R911 (POWER SET) clockwise and verify that the power output is increasing.

### 2.4 THERMAL PROTECTION

Step 1. Set R939 (CURRENT LIMIT) fully counterclockwise.

Step 2. Adjust R911 (POWER SET) to obtain the proper power set level for the radio under test. Connect an insulated jumper clip between the TEMP SENSE lead (orange wire) and the B- lead (black wire connected to C883 and C882, respectively, on the PA feedthrough plate). Key the transmitter and verify that the power output indication is now less than 25% of set power.

### 2.5 REFLECTED POWER (VSWR) PROTECTION

Step 1. Set R939 (CURRENT LIMIT) fully counterclockwise.

Step 2. Key the transmitter and adjust R911 (POWER SET) to obtain a normal power setting level.

Step 3. Remove the 50-ohm load from the radio. Briefly key the transmitter and verify that an output power indication of less than 50% is obtained.

### 2.6 POWER SET (R983), LOW POWER OUTPUT MODE

Step 1. Set R939 (CURRENT LIMIT) fully counterclockwise.

Step 2. Set R911 (POWER SET, High Power) to obtain nominal power output.

Step 3. Select a channel programmed for low output power.

Step 4. Set R983 (POWER SET, Low Power) fully counterclockwise.

Step 5. Key the transmitter and, observing the wattmeter, verify that an output power indication of zero is obtained. Rotate R983 clockwise and verify that the power output indication is increasing.

## 3. RF AMPLIFICATION TESTS

### 3.1 INJECTION

Step 1. Disconnect the rf drive signal to the exciter from the synthesizer (J700).

Step 2. Connect a 50-ohm-terminated rf millivoltmeter to the transmitter injection plug (P700) of the synthesizer. The residual rf drive to the exciter in the receive mode should be less than -15 dBm. Transmitter injection in the transmit mode should be greater than +16 dBm.

### 3.2 EXCITER

Step 1. Disconnect exciter output cable from the PA and connect it to a wattmeter and dummy load.

Step 2. Set R911 (POWER SET) and R939 (CURRENT LIMIT) to the mid position.

Step 3. Key up the transmitter and verify that the minimum output power does not exceed 1.5 watts.

### 3.3 POWER AMPLIFIER (HIGH AND LOW POWER MODES)

Step 1. Rotate R911 (POWER SET) fully clockwise and R939 (CURRENT LIMIT) fully counterclockwise. Key up the transmitter and verify that the output power does exceed the rated radio power by at least 20% on every high power output channel.

Step 2. Set R939 (CURRENT LIMIT) fully counterclockwise, and set R911 (POWER SET) for nominal rated output power. Set R983 (POWER SET) fully clockwise, select a low power output channel, and key the transmitter. Output power should exceed the rated low power (10 W) by at least 260% (power output minimum = 26 W).

**CAUTION**

Avoid extended keying of the transmitter while performing Step 2 since 2/3 of the full PA power gets dissipated in the attenuator.

## 4. POWER AMPLIFIER TROUBLESHOOTING GUIDE

### 4.1 GENERAL

This guide can be used to locate defects isolated to the *SYNTOR X* high-band power amplifier. The following checks assume that 13.4 volts dc are applied to the radio set through a standard cable kit and that all POWER CONTROL potentiometers (R911, R983) are set fully clockwise and CURRENT LIMIT potentiometer (R939) is set fully counterclockwise, with the radio set keyed on a defective channel (unless otherwise stated).

### 4.2 NO POWER OUTPUT OR POWER OUTPUT LESS THAN 20% OF RATED POWER

#### 4.2.1 Continuity Checks

Check the transmitter signal path continuity, as explained in the General Maintenance section of this manual.

#### 4.2.2 Voltage Checks

With the radio unkeyed and the receiver audio at a minimum, check for +13.3 V dc on the collectors. If one or more stages have zero voltage, check associated dc feed circuits for an open circuit.

#### 4.2.3 Individual Stage Current Checks

Check the collector currents drawn by all stages to determine if the normal value shown in Table 1 is drawn.

Step 1. If a stage is found with less than minimum Ic (see Table 1), check for shorts or defective components in that stage, then in the preceding and following stages.

Step 2. Where more than one stage indicates low current, check the earliest defective stage (toward the PA input) first.

Step 3. If all stages give a low current indication, check the exciter output. The exciter is defective if the output is less than 1.5 W.

*Table 1. Minimum Normal Current Indication (All POWER CONTROL Potentiometers Set Fully Clockwise)*

| Power Output | Transistor | Ic | 150-162 MHz | 162-174 MHz |
|---|---|---|---|---|
| 110 W/10 W | Q801 | Direct | 1.2A | 0.75A |
| | Q802 | Direct | 2.4A | 3.0A |
| | Q802 | Drop across R822 | 240 mV | 300 mV |
| | Q803-Q804 | Drop across R801 | 170 mV | 160 mV |
| | Q803-Q804 | Direct | 17A | 16A |
| | Q803-Q804 | Meter 5 | 17 uA | 16 uA |

**NOTE**

Direct current measurements taken by inserting ammeter into dc feed circuit from the common A+ connection.

4.3 POWER OUTPUT DOES NOT EXCEED THE RATED RADIO POWER BY 20% AT MAXIMUM POWER SETTINGS AND HIGH POWER OUTPUT MODE (110 W)

4.3.1 Check A+ and A− voltages at the collectors with the power amplifier operating. Use ***only*** a passive voltmeter or a VOM with 1.2 uH series chokes at the probe tips. With the power supply accurately set for 13.5 V dc, voltages on the transistor collectors should exceed the Table 2 values (all voltages measured with respect to the A− plating on the power amplifier board):

*Table 2. PA Collector Votlages for HLD4116A PA (110/10 W)*

| Transistor | Indication |
|---|---|
| Q801 | 12.0 V dc |
| Q802 | 11.8 V dc |
| Q803, Q804 | 11.8 V dc |

Step 1. If all voltages are low, recheck the power supply. If the power supply is satisfactory, check the feedthrough capacitors for poor solder connections and the front plug A+ and A− connections for good contact.

Step 2. If only one or two stages have low voltages, trace back through the dc-feeds of that stage, checking for bad connections or defective components. The maximum normal voltage drops are 0.3 V dc for R801, 0.5 V dc for R822, and less than 0.1 V dc for all other components in the dc-feed circuits.

4.3.2 Check the stage currents as outlined in paragraph 4.2.3.

4.3.3 If trouble in the finals (Q803, Q804) is indicated, or other approaches have failed, check the balance in the final amplifier by soldering a 2.7 V lamp (type 338, Motorola Part No. 65-82671G01) across R819 using #14 wire or a 0.1 inch wide copper strap or braid. If the lamp lights up to greater than half its normal brilliance, or flashes and burns out, there is a defect in one side of the parallel final amplifier circuitry. If such imbalance is indicated, the defective section can usually be isolated by shorting the base to emitter of one transistor (at the transistor body, opposite C825 or C826) with a screwdriver blade. The section that shows the *least* drop in power output (when shorted) is the one to be checked for defective components. If no obviously defective passive components, bad connections, or shorts can be located, make the following tests prior to considering the replacement of Q803 or Q804.

**CAUTION**

Remove all power from the radio set for the following tests.

Step 1. Check in-circuit base-emitter resistance on the suspect transistor(s). If *greater* than 1 ohm, coil L809 or L810 is bad.

**NOTE**

Place the negative potential lead from the ohmmeter on the transistor base for this test.

Step 2. If the resistance check shows that L809 and L810 are not defective, remove capacitor C825 or C826 and check it for shorts, both internally (with an ohmmeter), and externally (visual check for solder shorts on the capacitor or printed circuit board). If the capacitor or its connection is suspect, replace it and recheck the power output and balance before proceeding.

Step 3. If the capacitor is not defective, replace transistor Q803 or Q804 and reassemble the power amplifier.

**NOTE**

Whenever any gross imbalance is found and suspected faulty components are replaced, be sure to recheck balance after replacing components. Continue the investigation if imbalance has not been fully corrected.

4.3.4 With all power removed from the radio set, check for open base return on Q801 and Q802 by measuring in-circuit base-emitter resistance. The resistance should be less than 1 ohm on Q801 and less than 2.5 ohms on Q802.

**NOTE**

Place negative potential lead of ohmmeter on transistor base(s) for this test.

4.4 POWER OUTPUT DOES NOT EXCEED RATED RADIO POWER BY 260% WITH ALL POWER CONTROLS FULLY OPEN AND IN LOW POWER OUTPUT MODE (10 W)

**CAUTION**

Avoid extended keying of the transmitter while performing the following tests.

Step 1. With the transmitter in the low PO (power output) mode (10 W), check the transmitter signal path continuity and verify that this continuity ranges between 54 and 80 ohms.

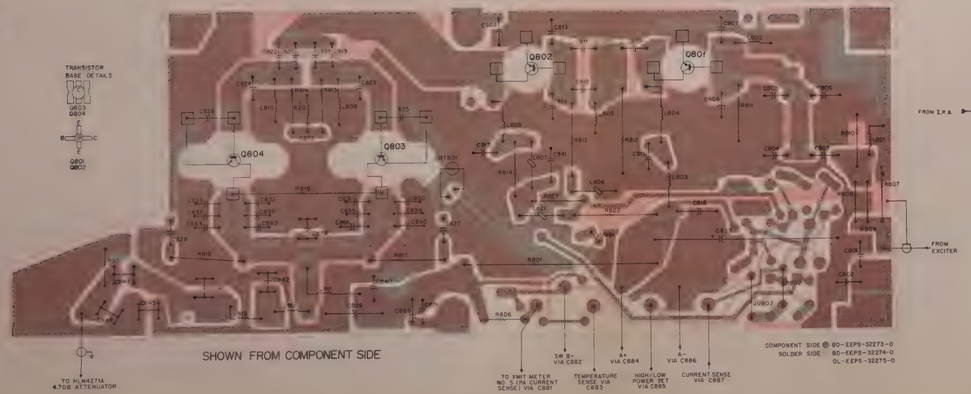
Step 2. Perform the checks outlined in paragraph 4.3.

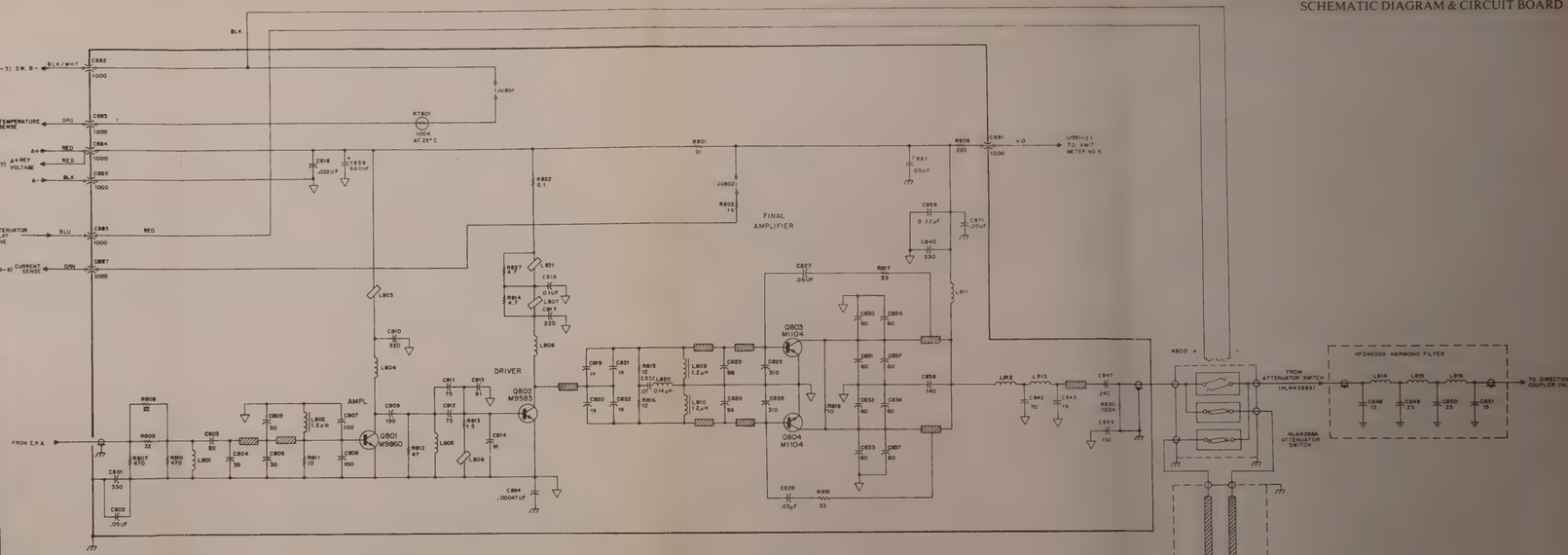
*Table 3. Transmitter Troubleshooting Chart (High and Low Power Output Modes)*

| Step | Symptom | Procedure | Normal Indication | If Normal | If Abnormal |
|---|---|---|---|---|---|
| 1 | Suspected transmitter failure | Measure rf output power at antenna connector | Rated power | Transmitter OK | High power — perform transmitter control and protection troubleshooting procedure. Low power — go to Step 3. No power — go to Step 2. |
| 2 | No output power | a. set all POWER SET controls fully clockwise and CURRENT LIMIT fully counterclockwise and observe meters 3 and 5. | Both greater than 10 uA | Go to Step 2b. | No indication — perform transmitter control and protection troubleshooting procedure. Meter 3 indication, but no meter 5 indication — go to Step 2g. |
| | | b. Measure dc voltage across antenna relay coil during Tx | 9.5 V dc | Go to Step 2c. | Check coil continuity (dc resistance ap- prox. 160 ohms). |
| | | c. Check reed switch continuity. | Continuous during Tx | Go to Step 2d. | Replace switch. |
| | | d. Check harmonic filter and output cable for shorts and discontinuities | See schematic diagram | Go to Step 2e. | Repair defective part(s). |
| | | e. Measure dc voltage across attenuator relay coil during Tx. | 9.0 V High PO mode, 0.0V low PO mode | Go to Step 2f. | Check relay driver stage (Q802); check coil continuity (approx. 134 ohms) |
| | | f. Check attenuator switch continuity, as indicated in the General Maintenance section of manual | Approx. zero ohms (High PO); 54-80 ohms (Low PO) | Perform PA troubleshooting procedure | Repair defective part(s). |
| | | g. Measure rf signal level at synthesizer output (J700) | + 16 dBm min. | Go to Step 2h. | Perform synthesizer troubleshooting procedure. |
| | | h. Measure rf power at exciter output. | 1.5 W min. | Perform PA troubleshooting procedure | Repair defective exciter. |
| 3 | Low output power | a. Set POWER SET controls fully clockwise and CURRENT LIMIT fully counterclockwise and observe meter 3 | Greater than 20 uA. | Go to Step 3b | Perform transmitter control and protection troubleshooting pro- cedure |
| | | b. Measure rf power at synthesizer output (J700) | + 16 dBm min. | Go to Step 3c. | Perform synthesizer troubleshooting procedure |
| | | c. Measure rf power at exciter output. | 1.5 W min. | Perform PA troubleshooting procedure. Go to Step 3d. | Repair defective exciter. |
| | | d. Perform transmit signal path test, as indicated in the General Maintenance sec- tion | Approx. 0 ohms (High PO), 54- 80 ohms (Low PO). | | Repair defective part(s). |

*Table 4. Transmitter Control and Protection Circuitry Troubleshooting Chart*

| Step | Symptom | Procedure | Normal Indication | If Normal | If Abnormal |
|---|---|---|---|---|---|
| 1 | No meter 3 or 5 with all controls wide open; (POWER SET clockwise, CURRENT LIMIT counterclockwise). | a. Disconnect exciter from synthesizer at J700; check for TX 9.5 V @ U901-8. | 9.5 V dc | Go to Step 1b. | a. Check PA ENABLE @ P401-10.<br>b. Check for synthesizer lock.<br>c. Check TX 9.5 V switch (Q1007).<br>d. Check PA ENABLE switches (Q5, Q6). |
| | | b. Measure output voltage at U901A-1. | > 3.3 V dc | Repair fault in control voltage amplifiers (Q903, 904). | Go to Step 1c. |
| | | c. Measure voltages at U901A, pins 2 and 3. | Pin 3 > Pin 2 | U901 defective | Check for shorts or opens in resistive feed circuits to pins 2 & 3. Check for defective transmission gate and shorted Q910. |
| 2 | Meter 3 reads max. of about 10 uA with all controls fully open. Little or no output power. | a. Disconnect exciter from synthesizer at J1151. Measure voltage of protection comparator output at U901B-7. | > 8 V dc | Troubleshoot Q905 circuit | Go to Step 2b. |
| | | b. Measure voltages to input of Q901B, pins 5 & 6. | Pin 5 > Pin 6 | U901 defective | Analyze and repair current limiter circuitry, Q906, Q907, Q908. |
| 3 | All controls inoperative and meter 3 gives 25 uA | a. Disconnect exciter from synthesizer at J115. Observe meter 3 in RX mode. | 0 uA | Go to Step 2b. | Repair fault in control voltage amplifiers, Q903 & Q904. |
| | | b. Set all controls fully open. Measure pins 2 & 3 of U901A in TX mode. | Pin 2 > Pin 3 | U901 defective | Look for defect in voltage reference network, R926, R927, R921, R911. Look for shorted transmission gate U501D. |
| 4 | Current limit (R939) and reflected power (VSWR) protection inoperative. | Q905 and associated circuitry probably open; analyze and repair. | | | |
| 5 | Current limit (R939) inoperative. | Disconnect exciter from synthesizer at J700. Unsolder sense line (GRN) from C888. Observe meter 3. | 15 uA | Check for short to A + of current sense line. | Analyze fault in current limit circuit Q906, Q907, Q908, and repair. |
| 6 | Reflected power (VSWR) protection inoperative. | Check and repair defect in reflected power detector components, R901, CR901, etc. | | | |
| 7 | Thermal protection inoperative | Check and repair defect in thermal protection components, R915, R930, and CR904. | | | |
| 8 | Power set (R911) inoperative. | Check and repair defect in forward power detector components, R902, CR902, etc. | | | |




NOTES :
1 UNLESS OTHERWISE SPECIFIED, CAPACITOR VALUES ARE IN PICOFARADS
2 INDICATES MICROSTRIP TRANSMISSION LINE.
3 INDICATES PA REF (A-)
INDICATES CHASSIS REF
4 ALL PARTS MAY BE REMOVED FROM THE TYP OF THE BOARD

CAUTION:
WHEN MOUNTING TRANSISTORS DO NOT OVERTIGHTEN BEYOND 5-7 INCH POUNDS OR DAMAGE TO TRANSISTORS MAY RESULT

MODEL COMPLEMENT

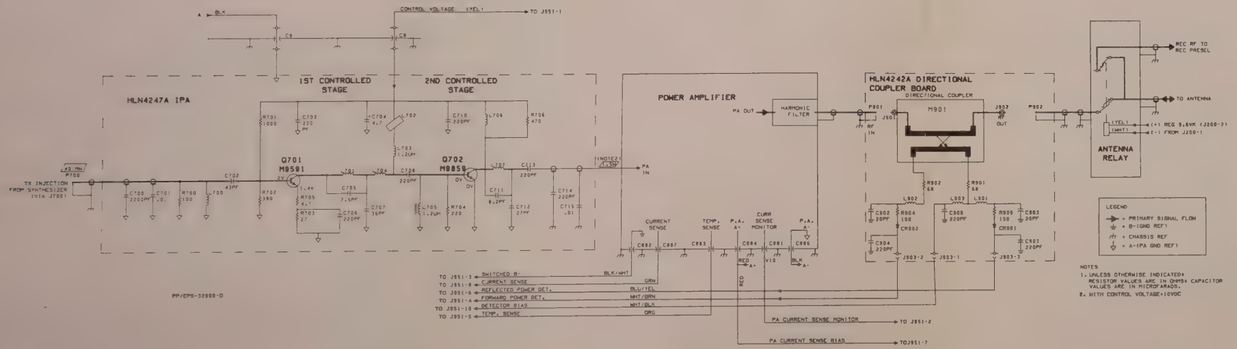
| | |
|---|---|
| HLN4289A | HARDWARE KIT (RGI-RGIV) |
| HLD4116A | PA BOARD (RII-RIV) |
| HLD4067A | POWER TRANSISTOR (RGII-RGIV) |
| HLN4046A | FEED-THROUGH PLATE |
| HLN4271A | 4.7 DB ATTENUATOR |
| HLN4268A | ATTENUATOR SWITCH |
| HF0400OA | HARMONIC FILTER |

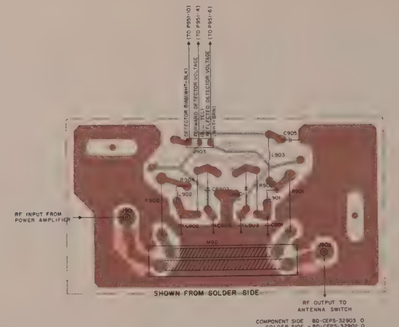
EEPS-32272-A

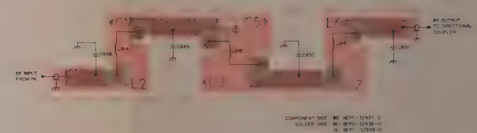
*HLD4116A 110 W/10 W Power Amplifier Schematic Diagram, Circuit Board Detail, and Parts Lists*
*Motorola No. PEPS-32990-O*
*(Sheet 1 of 3)*
*10/6/81-NPC*

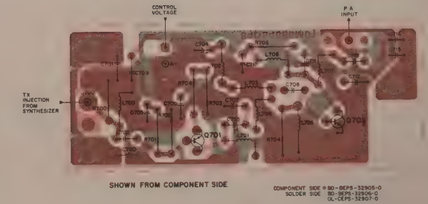
# HLN4247A IPA, HLN4242A DIRECTIONAL COUPLER & HFD4000A HARMONIC FILTER

SCHEMATIC DIAGRAM & CIRCUIT BOARDS




*HLD4116A 110 W/10 W Power Amplifier*
*Schematic Diagram, Circuit Board Detail, and Parts Lists*
*Motorola No. PEPS-32990-O*
*(Sheet 2 of 3)*
*10/6/81- NPC*

# parts list

HLD4116A Power Amplifier Board — PL-7618-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **capacitor, fixed: pF ± 5%; 500 V:** unless otherwise stated |
| C801 | 21-863629 | 330 ± 10% |
| C802 | 21-82372C10 | .05 ± 20%; 25 V |
| C803 | 21-83406D77 | 30 |
| C804 | 21-84493B59 | 39 |
| C805, 806 | 21-83406D77 | 30 |
| C807, 808 | 21-84493B65 | 100 |
| C809 | 21-84493B66 | 150 |
| C810 | 21-83596E10 | 220 ± 20%; 200 V |
| C811, 812 | 21-84493B63 | 75 |
| C813, 814 | 21-84493B64 | 91 |
| C816 | 8-82096J18 | 0.1 uF ± 10%; 250 V |
| C817 | 21-83596E10 | 220 ± 20% |
| C818 | 8-82096J08 | .022 uF ± 10%; 250 V |
| C819 thru 822 | 21-84493B35 | 19 |
| C823, 824 | 21-84715F26 | 56 |
| C827, 828 | 21-82372C10 | .05 uF ± 20%; 25 V |
| C830 thru 837 | 21-80169A74 | 60 |
| C838 | 21-84395B47 | 140; 350 V |
| C839 | 23-83210A22 | 860 uF + 150-10%; 25 V |
| C840 | 21-863629 | 330 ± 10%; 5 V |
| C841 | 21-84366F12 | 0.1 uF ± 10%; 250 V |
| C842 | 21-84395B40 | 70; 350 V |
| C843 | 21-84395B41 | 19; 350 V |
| C845 | 21-84395B46 | 150; 250 V |
| C847 | 21-84395B35 | 240 ± 10%; 350 V |
| C852 | 21-83596E21 | .01 uF + 80-20%; 200 V |
| C859 | 8-82096J20 | 0.22 uF ± 10%; 250 V |
| C861 | 21-82372C04 | .05 uF + 80-20%; 25 V |
| C864 | 21-82187B07 | .00047 uF ± 10% |
| C865 | 21-83596E10 | 220 ± 20% |
| C871 | 21-82372C04 | .05 uF + 80-20%; 25 V |
| C872 | 21-83596E21 | .01 uF + 80-20%; 200 V |
| | | **coil, rf:** |
| L801 | 24-83884G01 | 3-1/2 turns |
| L802 | 24-82723H27 | 1.2 uH |
| L803 | 24-80036A02 | ferrite bead, 1/2 turn |
| L804 | 24-80277A01 | 12-1/2 turns |
| L805 | 7-80062B02 | 12 turn |
| L806, 807 | 24-80036A02 | ferrite bead, 1/2 turn |
| L808 | 24-80277A05 | 1-1/2 turns |
| L809, 810 | 24-82723H27 | 1.2 uH |
| L811 | 24-80277A04 | 7- 1/2 turns |
| L812 | 7-80062B04 | 1/2 turn |
| L813 | 24-80277A08 | 1-1/2 turns |
| L820 | 24-82723A24 | 140 nH |
| L821 | 24-80036A02 | ferrite bead, 1/2 turn |
| | | **resistor, fixed ± 5%; 1/2 W:** unless otherwise stated |
| R801 | 17-80165C01 | .01; 10 W |
| R802 | 6-124A49 | 1k; 1/4 W |
| R806 | 6-124C33 | 220 ± 10%; 1/4 W |
| R807 | 6-125A41 | 470 |
| R808, 809 | 6-124A09 | 22; 1/4 W |
| R810 | 6-125A41 | 470 |
| R811 | 6-125C01 | 10 ± 10% |
| R812 | 6-127C17 | 47 ± 10%; 2 W |
| R813 | 17-82036G07 | 1.5 ± 10%; 2 W |
| R814 | 6-125B61 | 4.7 |
| R815, 816 | 6-125C03 | 12 ± 10% |
| R817, 818 | 17-82036G11 | 33 ± 10%; 2 W |
| R822 | 17-82291B24 | 0.1; 3 W |
| R827 | 6-125B61 | 4.7 |
| R830 | 6-124C97 | 100k ± 10%; 1/4 W |
| | | **thermistor:** |
| RT801 | 6-83600K09 | 100k @ 25 ° C |

**note:** For parts not listed in the above parts list, refer to the mechanical parts section.

HLN4247A Intermediate Power Amplifier — PL-7629-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **capacitor, fixed: pF ± 20%; 500 V** unless otherwise stated |
| C700 | 21-11015B05 | 200 |
| C701 | 21-11015A07 | .01 uF + 80-20%, 200 V |
| C702 | 21-11014A40 | 43 ± 5% |
| C703 | 21-11015B05 | 220 |
| C704 | 23-11013D55 | 4.7 uF; 20 V |
| C705 | 21-11014H22 | 7.5 ± .05 pF |
| C706 | 21-11015B05 | 220 |
| C707 | 21-11014H36 | 33 ± 5% |
| C708 | 21-11015B05 | 220 |
| C710 | 21-11015B05 | 220 |
| C711 | 21-11014H23 | 8.0 ± .25 pF |
| C712 | 21-11014H35 | 27 ± 5% |
| C713, 714 | 21-11015B05 | 220 |
| C715 | 21-11015A07 | .01 uF + 80-20%, 200 V |
| | | **connector, receptacle:** |
| J700 | 9-84231B03 | phono, female |
| | | **coil, rf:** |
| L700 | 24-83884G01 | 3-1/2 turns, coded red |
| L701 | 24-83884G08 | 5-12 turns, coded org |
| L702 | 24-80036A01 | 1/2 turn |
| L703 | 24-82723H01 | 1.2 uH |
| L704 | 24-83884G07 | 2-1/2 turns, coded grn |
| L705 | 24-83961B02 | 5 turns, coded grn |
| L706 | 24-83884G06 | 4-1/2 turns, coded wht |
| L707 | 24-83884G07 | 2-1/2 turns, coded grn |
| | | **connector, plug:** |
| P700 | 9-84231B03 | female: 3-contact |
| | | **transistor: (see note)** |
| Q701 | 48-869591 | NPN; type M9591 |
| Q702 | 48-869859 | NPN; type M9859 |
| | | **resistor, fixed: ± 5%; 1/4 W:** |
| R700 | 6-11009C25 | 100 |
| R701 | 6-11009C49 | 1k |
| R702 | 6-11009C39 | 390 |
| R703 | 6-11009C11 | 27 |
| R704 | 6-11009C33 | 220 |
| R705 | 6-124B61 | 4.7 |
| R706 | 6-11009C41 | 470 |

**note:** For optimum performance, diodes, transistors, and integrated circuits must be ordered by Motorola part numbers.

HLN4242A Directional Coupler Board — PL-7628-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **capacitor, fixed: pF; 500 V:** |
| C901, 902 | 21-11014H32 | 20 ± 5% |
| C903, 904, 905 | 21-11015B05 | 220 ± 20% |
| | | **diode: (see note)** |
| CR901, 902 | 48-84616A01 | hot carrier |
| | | **connector, receptacle:** |
| J901, 902 | 24-84393B04 | female, single contact |
| J903 | 28-84324M02 | male, 3-contact |
| | | **coil, rf:** |
| L901, 902 | 24-84393B04 | 7-1/2 turns |
| L903 | 24-82723H01 | 1.2 uH |
| | | **resistor, fixed:** |
| R901, 902 | 6-125A21 | 68 ± 5% 1/2 W |
| R904, 905 | 6-11009C29 | 150 ± 5% 1/4 W |

**note:** For optimum performance, diodes, transistors, and integrated circuits must be ordered by Motorola part numbers.

HLN4268A Attenuator Switch — PL-7621-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **relay, coil:** |
| K800 | 24-84941E01 | dc resist. = 134 ohms ± 10% |

**note:** For parts not listed in the above parts list, refer to the mechanical parts section.

HLN4244A IPA Feedthru Plate — PL-7627-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **capacitor, fixed:** |
| C8, 9 | 21-82812H01 | feedthru, 470 ± 10%, 500 V |

HLN4046A PA Feed-Thru Plate — PL-7620-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **capacitor, feedthru:** |
| C861 thru 887 | 21-82812H03 | 1000 pF + 100-0%, 500 V |

HLN4269A PA Hardware Kit — PL-7619-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **capacitor, fixed:** |
| C825, 826 | 21-80069B01 | 310 |

**note:** For parts not listed on the above parts list, refer to the mechanical parts section

HFD4000A Harmonic Filter — PL 7622-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **capacitor, fixed:** |
| C848 | 21-835358 | 15 pF ± 10%; 500 V |
| C849, 850 | 21-82860E16 | 25 pF ± 10%; 850 V |
| C851 | 21-835358 | 15 pF ± 10%; 500 V |
| | | **coil, rf:** |
| L814 | 24-80066A04 | 5 1/2-turns |
| L815 | 24-80066A03 | 6 1/2-turns |
| L816 | 24-80066A04 | 5 1/2-turns |

**note.** For parts not listed in the above parts list refer to the mechanical parts section

HLD4067A Power Transistor Kit — PL 6858-O

| REFERENCE SYMBOL | MOTOROLA PART NO | DESCRIPTION |
|---|---|---|
| | | **transistor: (see note)** |
| Q801 | 48-869860 | NPN; type M9860 |
| Q802 | 48-869583 | NPN; type M9583 |
| Q803,804 | 48-84411L04 | NPN, type M1104 |
| | | **resistor, fixed:** |
| R819 | 6-127C01 | 10 ± 10%, 2 W |

**note:** For optimum performance, diodes, transistors, and integrated circuits must be ordered by Motorola part numbers

*HLD4116A 110 W/10 W Power Amplifier Schematic Diagram, Circuit Board Detail, and Parts Lists*
*Motorola No. **PEPS-32990-O***
*(Sheet 3 of 3)*
*10/6/81- NPC*

# HLN4270A INTERFACE BOARD

## 1. DESCRIPTION

The HLN4270A Interface Board contains circuits that are required to implement three different radio options:

- Front/rear EMS control system
- *Systems 90* single-tone encoder
- High/low power transmit.

Interconnection with the radio is achieved by employing eight color-coded wires equipped with individual push-pin connectors and a two-pin connector jack. These wires are connected to various terminals on the personality board, whereas the jack mates with a plug on the wiring harness from the common circuits board to the transmitter power amplifier feed-through plate.

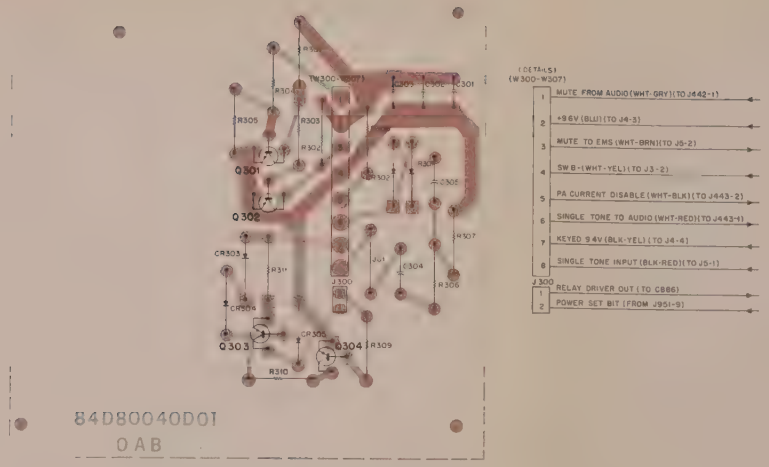
## 2. THEORY OF OPERATION

2.1 Transistors Q301 and Q302 provide a +0.3 V ($\overline{\text{MUTE}}$) or +9.6 V (MUTE) signal to mute the rear control head in an EMS system. This signal is derived by monitoring the AUDIO ENABLE MONITOR test point (J442-1) on the personality board. When the audio signal is muted, the AUDIO ENABLE MONITOR test point is at +9.6 V; consequently Q301 turns on and Q302 turns off, providing a +9.6 V signal to mute the EMS rear control head, via the personality board and the control cable kit.

2.2 R308, a 5.6-kilohm resistor connected to J443-2, is used to enable the audio at all times for certain *Systems 90* options (such as the single-tone encoder) that requires audio operation during standby mode. Normally, the bias current to the audio output predrivers is cut off during MUTE, to reduce the standby current drain. By enabling this bias current in the standby mode, R308 prepares the audio for operation in the MUTE mode.

2.3 A network consisting of C304, C305, R306, R307, CR301, and CR302 is used to interface the tone generated by the *Systems 90* optional single-tone encode card (in the control head) with the audio signal from the radio (via the personality board) so that the tone can be heard in the speaker. This option can be defeated by removing jumper JU1, which is connected between J5-1 and C304.

2.4 Q303 provides current drive to the rf switch in the high/low power attenuator in radios equipped with such an option. When the transmitter of a radio equipped with this option is keyed (i.e., PTT pushbutton is depressed), K9.5 V goes to +9.5 V and Q303 turns on if the POWER LEVEL bit from the common circuits board is high (approx. 5 V); subsequently, Q304 turns on and the radio switches to the HIGH POWER mode. If, on the other hand, the POWER LEVEL bit (from the common circuits board) is low (approx. 0.3 V), both transistors (Q303 and Q304) stay turned off, and the transmitter operates in the LOW POWER mode.




SHOWN FROM SOLDER SIDE

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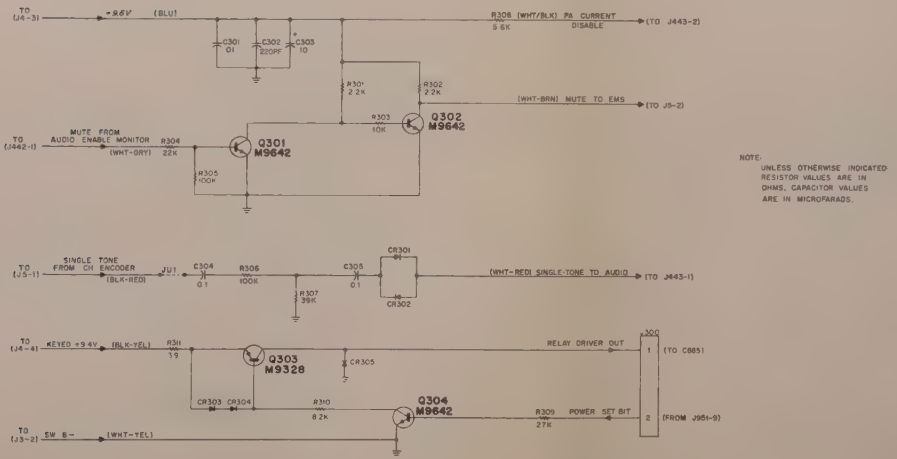
COMPONENT SIDE = 8D-CEPS-32917-O
OL-CEPS-32918-O




CEPS-32915-A

# parts list

HLN4270A Interface Board — PL-7590-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **capacitor, fixed:** |
| C301 | 21-11015A07 | .01 uF +80-20%; 100 V |
| C302 | 21-11015B05 | 220 pF ± 10%; 100 V |
| C303 | 23-11013E57 | 10 uF ± 20%; 20 V |
| C304, 305 | 8-84637L37 | 0.1 uF ± 5%; 50 V |
| | | **diode: (see note)** |
| CR301 thru 305 | 48-83654H01 | silicon |
| | | **connector, plug:** |
| J300 | 28-84318M06 | male, 2 contact |
| | | **transistor: (see note)** |
| Q301, 302 | 48-869642 | NPN, type M9642 |
| Q303 | 48-869328 | PNP; type M9328 |
| Q304 | 48-869642 | NPN; type M9642 |
| | | **resistor, fixed ± 5%: 1/4 W; unless otherwise stated** |
| R301, 302 | 6-11009A57 | 2.2k |
| R303 | 6-11009A73 | 10k |
| R304 | 6-11009A81 | 22k |
| R305, 306 | 6-11009A97 | 100k |
| R307 | 6-11009A67 | 39k |
| R308 | 6-11009A67 | 5.6k |
| R309 | 6-11009C83 | 27k |
| R310 | 6-11009C71 | 8.2k |
| R311 | 6-124B59 | 3.9 |
| | | **cable:** |
| W300 | 1-80708T08 | Wire and Lug Assembly, (WHT-BRN) includes: |
| | 9-84279D01 | CONTACT, female |
| | 29-83167C01 | TERMINAL, strain relief |
| | 37-82603D60 | SLEEVING, No blank |
| W301 | 1-80708T09 | Wire and Lug Assembly, (WHT-RED) includes: |
| | 9-84279D01 | CONTACT, female |
| | 29-83167C01 | TERMINAL, strain relief |
| | 37-82603D60 | SLEEVING, No blank |
| W302 | 1-80708T10 | Wire and Lug Assembly, (WHT-YEL) includes |
| | 9-84279D01 | CONTACT, female |
| | 29-83167C01 | TERMINAL, strain relief |
| | 37-82603D60 | SLEEVING, No blank |
| U303 | 1-80708T11 | Wire and Lug Assembly, (WHT-BLK) includes |
| | 9-84279D01 | CONTACT, female |
| | 29-83167C01 | TERMINAL, strain relief |
| | 37-82603D60 | SLEEVING, No blank |
| W304 | 1-80708T12 | Wire and Lug Assembly, (WHT-GRAY) includes: |
| | 9-84279D01 | CONTACT, female |
| | 29-83167C01 | TERMINAL, strain relief |
| | 37-82603D60 | SLEEVING, No. blank |
| W305 | 1-80708T13 | Wire and Lug Assembly, (BLK-WHT) includes |
| | 9-84279D01 | CONTACT, female |
| | 29-83167C01 | TERMINAL, strain relief |
| | 37-82603D60 | SLEEVING, No. blank |
| W306 | 1-80708T14 | Wire and Lug Assembly, (BLK-YEL) includes. |
| | 9-84279D01 | CONTACT, female |
| | 29-83267C01 | TERMINAL, strain relief |
| | 37-82603D60 | SLEEVING, No. blank |
| W307 | 1-80708T30 | Wire and Lug Assembly, (VIO-BLU) includes |
| | 9-84279D01 | CONTACT, female |
| | 29-83267C01 | TERMINAL, strain relief |
| | 37-82603D01 | SLEEVING, No. 1 |
| | | **mechanical parts** |
| | 42-10217A02 | STRAP TIE |
| | 75-82200H17 | PAD, oscillator |

**note:** For optimum performance, diodes, transistors, and integrated circuits must be ordered by Motorola part numbers.

*HLN4270A Interface Board*
*Schematic Diagram, Circuit Board Detail, and Parts List*
*Motorola No. PEPS-32919-O*
*10/6/81- NPC*

# COMMON CIRCUITS BOARD

## 1. DESCRIPTION

1.1 The common circuits board (as shown in the schematic diagram appended to the end of this section) consists of the following circuits: (a) rf power control, (b) squelch circuit, (c) IDC, and (d) regulator.

1.2 Because of the functions of these circuits, the theory of operation and troubleshooting information associated with each circuit are presented in the following sections of this manual.

- rf power control (Transmitter section)
- squelch circuit (Receiver section)
- IDC (Synthesizer section)
- regulator (Common Circuits Board section)

## 2. THEORY OF OPERATION (REGULATOR)

### 2.1 INTRODUCTION

The regulator provides the radio with the voltages required. It consists of: (a) +9.6 V regulator, (b) +5.0 V regulator, (c) reference circuit, and (d) shut-back circuit.

### 2.2 REFERENCE CIRCUIT

The reference circuit employs a Zener diode (which forms part of HY1001), an operational amplifier (U1001B), and a factory-adjusted resistor network to provide a reference voltage of approximately 7.0 V at its output (U1001B-4). This reference output voltage is used to generate both the 5.0 V and 9.6 V supply voltages.

### 2.3 9.6 V REGULATOR

The 9.6 V regulator is protected against short circuits. If a short circuit occurs in the regulator, it will forward-bias CR1002, thus causing it to switch on and remove the drive power from output transistor Q1001.

### 2.4 5.0 V REGULATOR

The 5.0 V regulator is protected against excessively high output current levels. This is achieved by using a foldback current-limiting circuit that senses the voltages across R1002 and R1003. If the output current level reaches a predetermined level, Q1003 switches on, blocking the drive to output transistor Q1002.

### 2.5 SHUTBACK CIRCUIT

2.5.1 The shutback circuit is designed to turn off both regulators (the 5.0 V and the 9.6 V) whenever the supply voltage rises above (or goes below) a predetermined level. If the supply voltage reaches 20.5 V, CR1005 turns on, causing Q1006 to turn on. Consequently, Q1005 loses its input drive, thus causing the 9.6 V regulator to turn off. Moreover, this will also forward bias CR1003, thus causing the 5.0 V regulator to turn off.

2.5.2 When the supply voltage (SW A+) falls below 9.0 V, U1001A switches states, causing Q1006 to turn on and, consequently. both regulators to turn off. In this case, CR1004 causes the reference voltage to U1001A-1 to change when in the shutback mode. Consequently, both regulators will remain shut off until the supply voltages rise at least 1 volt above the critical level of 9.0 V.

## 3. REGULATOR TROUBLESHOOTING PROCEDURE

The regulator troubleshooting procedure consists of the following three procedures:

- failure of both the 5.0 V and 9.6 V regulators
- failure of only the 5.0 V regulator
- failure of only the 9.6 V regulator.

### 3.1 FAILURE OF BOTH REGULATORS

Step 1. Inspect P401 and the main front plug and verify that they are properly inserted.

Step 2. Measure A+ at P401 on the common circuits board. The normal indication is 10.5 to 16 V. If the A+ indication is present but outside the normal range, the low or high-line shutdown circuit may have been activated, shutting off the regulators. Adjust A+ to the proper voltage and re-check the regulators outputs. If A+ is not present, check continuity of the A+ and ground lines to isolate the fault.

Step 3. Measure the voltage at the Q1006 collector. A normal indication should be less than 0.6 V. If an incorrect indication is obtained, the shutback circuit should be repaired.

Step 4. Measure the voltage at HY1001-9. An indication of 7 +0.1 V should be obtained. If an incorrect indication is obtained, the 7 V reference circuit should be repaired.

**NOTE**

If the above-outlined procedure fails to remedy the problem, then each regulator should be separately repaired.

### 3.2 FAILURE OF 5 V REGULATOR

Step 1. Check the output of the 9.6 V regulator at P401-11 and verify that an indication of 9.6 ±0.1 V is obtained. If the indication is incorrect, refer to the preceding procedure.

Step 2. With the radio turned off, check the resistance between P401-12 and ground and verify that an indication of greater than 100 ohms is obtained. If the indication is incorrect, make the necessary checks to isolate the fault; the fault may not necessarily be on the common circuits board.

Step 3. With the power turned on, measure the voltage difference between U1001-12 and P401-12 and verify that an indicaiton of less than 2.5 V is obtained. If the indication is correct proceed to Step 5, otherwise go to the following step.

Step 4. Isolate the component with the excessive voltage drop. An excessive drop across R1009 may be caused by:

- excessive Q1002 base current because of a defective transistor or open collector lead
- a fault in the 5 V current limiter circuit (Q1003, R1004, R1005, R1016) causing Q1003 to turn on
- a shorted printed circuit board runner
- a defective R1009.

An excessive drop across Q1002 or R1002 is probably due to a fault in the component with the abnormal voltage drop.

Step 5. Measure the voltage at U1001-13 and verify that an indication of 7 ±0.1 V is obtained. If the proper indication is obtained, replace HY1001 or U1001; if the indication is incorrect, repair the 7 V reference circuit.

Step 6. Measure the voltage at HY1001-9 and verify that an indication of 7 ±0.1 V is obtained. If the proper indication is obtained. replace HY1001 or U1001; if the indication is incorrect, repair the 7 V reference circuit.

Step 7. Measure the voltage difference between U1001-14 and P401-12 and verify that an indication of 0 V is obtained. If the indication is correct, go to the next step; otherwise proceed as follows: if CR1003 is forward biased, repair the shutback circuit; otherwise replace R1010 or U1001.

Step 8. Measure the voltage at U1001-12 and determine why the feedback loop does not function properly.

### 3.3 FAILURE OF 9.6 V REGULATOR

Step 1. Check and verify that the 5 V regulator output voltage at P401-12 is 5.0 V. If the indication is correct go to the next step; otherwise refer to the procedure entitled Failure of Both Regulators.

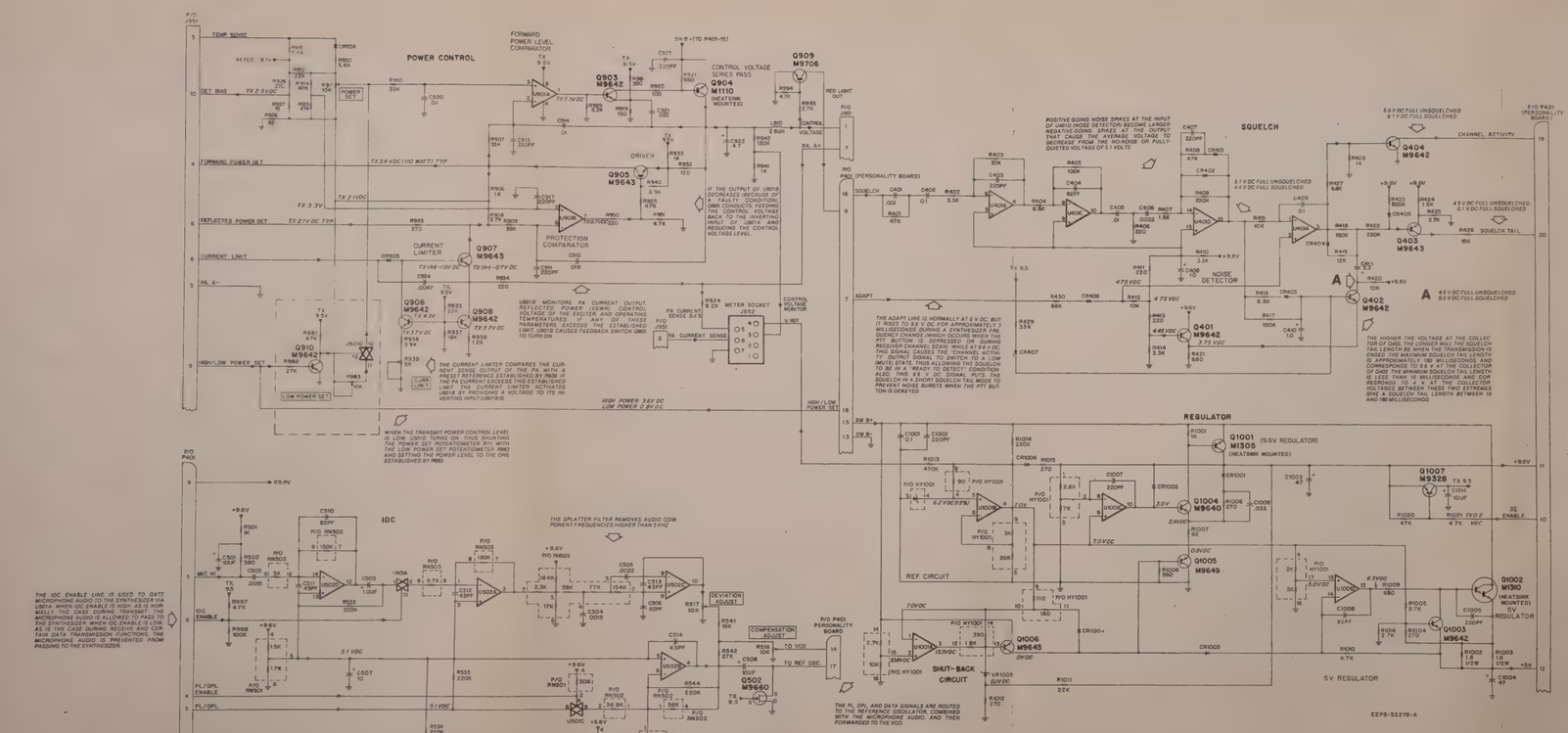
Step 2. Check the 9.6 output voltage at P401-11 and verify that an indication of 9.6 ±0.1 V is obtained. If the indication is too low, go to Step 3; if too high go to Step 6.

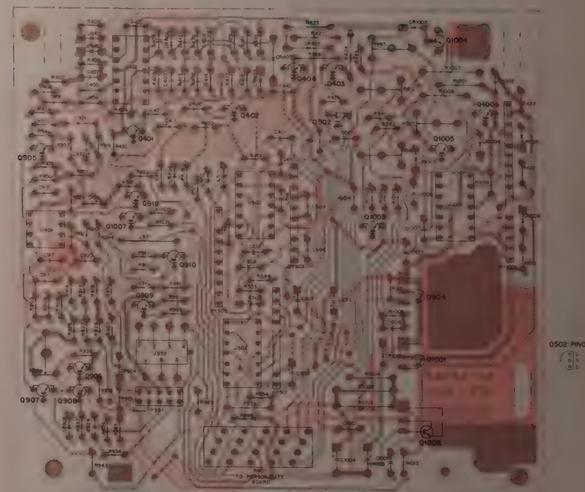
Step 3. With the radio turned off, check the resistance between P401-11 and ground. If a correct indication greater than 30 ohms is obtained, go to the next step; otherwise make the necessary checks to isolate the fault, which may not necessarily be on the common circuits board.

Step 4. With power turned on, measure the voltage at Q1006 base and verify that an indication greater than 10 V is obtained. If the proper indication is obtained, go to the next step; otherwise replace HY1001, U1001, or Q1006. A voltage higher than 2.5 V but lower than 10 V indicates that Q1006 may be defective.

Step 5. Replace Q1001 or repair the circuit board.

Step 6. Measure the voltage at Q1006 base and verify that the voltage is less than 0.5 V. If the indication is correct, replace Q1001 or repair the circuit board; otherwise, replace U1001 or HY1001.




NOTES

1. UNLESS OTHERWISE INDICATED, RESISTOR VALUES ARE IN OHMS, CAPACITOR VALUES IN MICROFARADS.
2. INTEGRATED CIRCUITS ON THIS BOARD ARE CMOS DEVICES. CONSEQUENTLY, PROPER CARE SHOULD BE TAKEN WHILE HANDLING THESE DEVICES.
3. TYPES AND CONNECTIONS FOR THE INTEGRATED CIRCUITS USED ON THIS BOARD ARE AS FOLLOWS

| REF. DESIG. | TYPE | VCC(PIN) | GND(PIN) | DESCRIPTION |
|---|---|---|---|---|
| U401, 502 | 2914/CK 009 OR 8413/CK 009 | +9.6 V (11) | (7) | QUAD OP AMP |
| U501 | 8413/CK 009 OR 7900 | +9.6 V (14) | (7) | QUAD TRANSMISSION GATE |
| U1001 | 2914/CK 009 OR 8701/4 | + A (11) | (7) | QUAD OP AMP |
| U901 | 8701/2 | TX 9.5 V (8) | (4) | DUAL OP AMP |

4. ALL VOLTAGES SHOWN ARE REFERENCED TO A
5. ALL VOLTAGES SHOWN ON THE RF POWER CONTROL ARE MEASURED UNDER THE FOLLOWING CONDITIONS:
   (A) 13.8 A+ VOLTAGE
   (B) 50 OHM RADIO TERMINATION
   (C) 110 WATT SET POWER

METERING INDICATIONS

| METER # | FUNCTION | NORMAL INDICATION (APPROX.) |
|---|---|---|
| 2 | PA CONTROL VOLTAGE | 10-28 VA |
| 4 | REFERENCE VOLTAGE | 15 VA |
| 5 | REGULATORS COMMON COLLECTOR CURRENT | 1 VA — 10 VA FOR 110 W POWER OUTPUT |

*Common Circuits Board Schematic Diagram, Circuit Board Detail, and Parts List*
*Motorola No. PEPS-32280-O*
*(Sheet 1 of 2)*
*10/6/81- NPC*

COMMON CIRCUITS BOARD

# parts list

HLN4240A Common Circuit Boards — PL-7611-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **capacitor, fixed: uF ± 10%; 100 V; unless otherwise stated** |
| C401 | 8-11017B01 | .001 ± 5%; 50 V |
| C402 | 8-84637L37 | 0.1 ± 5%; 50 V |
| C403 | 21-11015B05 | 220 pF |
| C404 | 21-11014B47 | 82 pF ± 5% |
| C405 | 8-11017B08 | .01; 50 V |
| C406 | 8-11017A03 | .0022 ± 5%; 50 V |
| C407 | 21-11015B05 | 220 pF |
| C408 | 23-11013E57 | 10 ± 20%; 25 V |
| C409 | 8-11017B08 | .01; 50 V |
| C410 | 23-11013F57 | 1 ± 20%; 35 V |
| C411 | 23-11013F59 | 2.2 ± 20%; 35 V |
| C501 | 23-11013E57 | 10 ± ; 25 V |
| C502 | 8-11017A02 | .0015 ± 5%; 50 V |
| C503 | 23-11013F57 | 1 ± 20%; 35 V |
| C504 | 8-11017A02 | .0015 ± 5%; 50 V |
| C505 | 8-11017A03 | .0022 ± 5%; 50 V |
| C506 | 21-11014B47 | 82 pF ± 5% |
| C507, 508 | 23-11013E57 | 10 ± 20%; 25 V |
| C510 | 21-11014B47 | 82 pF ± 5% |
| C511, 512, 513, 514 | 21-11014H40 | 43 pF ± 5% |
| C811 | 21-11015B05 | 220 pF |
| C812 | 8-11017B10 | .018 ± 5%; 50 V |
| C813 | 21-11015B05 | 220 pF |
| C814 | 8-11017B08 | .01; 50 V |
| C817 | 21-11015B05 | 220 pF |
| C820 | 21-11015A07 | .01 + 80-20% |
| C821 | 8-11017B11 | .022 ± 5%; 50 V |
| C822 | 23-11013D09 | 4.7 ± 20%; 20 V |
| C823 | 21-11015B05 | 220 pF |
| C824 | 8-11017B06 | .0047; 50 V |
| C1001 | 8-84637L37 | 0.1 ± 5% |
| C1002 | 21-11015B05 | 220 pF |
| C1003, 1004 | 23-84538G06 | 47 ± 20%; 20 V |
| C1005 | 21-11015B05 | 220 pF |
| C1006 | 8-11017B13 | .033; 50 V |
| C1007 | 21-11015B05 | 220 pF |
| C1008 | 21-11014B47 | 82 pF ± 5% |
| C1011 | 23-11013E57 | 10 ± 20%; 25 V |
| | | **diode: (see note)** |
| CR401 thru 407 | 48-83654H01 | silicon |
| CR904, 905 | 48-83654H01 | silicon |
| CR1001 thru 1004 | 48-83654H01 | silicon |
| CR1006 | 48-83654H01 | silicon |
| | | **connector, receptacle:** |
| J951 | 28-83186M03 | male, 9 contact |
| J952 | 9-84207B01 | female, 7 contact |
| | | **coil, rf:** |
| L910 | 24-82835G08 | choke, 2.6 uH; coded red-blu-gold |
| | | **connector, plug:** |
| P401 | 30-83602M01 | CABLE, ribbon; includes: female connector |
| | | **transistor: (see note)** |
| Q401, 402 | 48-869642 | NPN; type M9642 |
| Q403 | 48-869643 | PNP; type M9643 |
| Q404 | 48-869642 | NPN; type M9642 |
| Q502 | 48-869660 | field-effect; type M9660 |
| Q903 | 48-869642 | NPN; type M9642 |
| Q904 | 48-84411L10 | PNP; type M1110 |
| Q905 | 48-869643 | PNP; type M9643 |
| Q906 | 48-869642 | NPN; type M9642 |
| Q907 | 48-869643 | PNP; type M9643 |
| Q908, 909, 910 | 48-869642 | NPN; type M9642 |
| Q1001 | 48-84413L05 | PNP; type M1305 |
| Q1002 | 48-84413L10 | NPN; Darlington; type M1310 |
| Q1003 | 48-869642 | NPN; type M9642 |
| Q1004 | 48-869640 | NPN; type M9640 |
| Q1005 | 48-869649 | PNP; type M9649 |
| Q1006 | 48-869643 | PNP; type M9643 |
| Q1007 | 48-869328 | PNP; type M9328 |
| | | **resistor, fixed ± 5%; 1/4 W; unless otherwise stated** |
| R401 | 6-11009E89 | 47k |
| R402 | 6-11009E61 | 3.3k |
| R403 | 6-11009E85 | 33k |
| R404 | 6-11009E69 | 6.8k |
| R405 | 6-11009E97 | 100k |
| R406 | 6-11009E33 | 220 |
| R407 | 6-11009E53 | 1.5k |
| R408 | 6-11009E89 | 47k |
| R409 | 6-11009F06 | 220k |
| R410 | 6-11009E61 | 3.3k |
| R411 | 6-11009E33 | 220 |
| R412 | 6-11009E73 | 10k |
| R413 | 6-11009E33 | 220 |
| R414 | 6-11009E61 | 3.3k |
| R415 | 6-11009E73 | 10k |
| R416 | 6-11009E69 | 6.8k |
| R417, 418 | 6-11009F02 | 150k |
| R419 | 6-11009E75 | 12k |
| R420 | 6-11009E73 | 10k |
| R421 | 6-11009E45 | 680 |
| R422 | 6-11009F06 | 220k |
| R423 | 6-11009D20 | 820k |
| R424 | 6-11009C53 | 1.5k |
| R425 | 6-11009E59 | 2.7k |
| R426 | 6-11009E77 | 15k |
| R427 | 6-11009C69 | 6.8k |
| R428 | 6-11009E49 | 1k |
| R429 | 6-11009E85 | 33k |
| R430 | 6-11009E93 | 68k |
| R501 | 6-11009E49 | 1k |
| R502 | 6-11009E42 | 560 |
| R516, 517 | 18-83311K06 | variable; 10k |
| R533, 534 | 6-11009F06 | 220k |
| R535 | 6-11009D06 | 220k |
| R541 | 6-11009E79 | 18k |
| R542 | 6-11009E83 | 27k |
| R544 | 6-11009F06 | 220k |
| R906 | 6-11009E49 | 1k |
| R907 | 6-11009E85 | 33k |
| R908 | 6-11009E57 | 2.7k |
| R909 | 6-11009E87 | 39k |
| R910 | 6-11009E85 | 33k |
| R911 | 18-83311K06 | variable; 10k |
| R912 | 6-11009E81 | 22k |
| R913, 914 | 6-11009E85 | 47k |
| R915 | 6-11009E66 | 5.1k |
| R918 | 6-11009E39 | 390 |
| R919 | 6-11009E29 | 150 |
| R920 | 6-11009E25 | 100 |
| R921 | 6-11009E43 | 560 |
| R924 | 6-11009E71 | 8.2k |
| R925 | 6-11009E65 | 4.7k |
| R926 | 6-11009E35 | 270 |
| R927 | 6-11009E05 | 15 |
| R928 | 6-11009E23 | 82 |
| R929 | 6-11009E71 | 8.2k |
| R930 | 6-11009E67 | 5.6k |
| R932 | 6-11009E27 | 120 |
| R933 | 6-11009E49 | 1k |
| R934 | 6-11009E33 | 220 |
| R936 | 6-11009E81 | 22k |
| R936 | 6-11009E51 | 1.2k |
| R937 | 6-11009E79 | 18k |
| R938 | 6-11009E63 | 3.9k |
| R939 | 18-83311K05 | variable; 5k |
| R940 | 6-11009E63 | 3.9k |
| R941 | 6-11009E49 | 1k |
| R942 | 6-11009E99 | 120k |
| R943 | 6-11009E35 | 270 |
| R950 | 6-11009E33 | 220 |
| R951 | 6-11009E65 | 4.7k |
| R981 | 6-11009E65 | 4.7k |
| R982 | 6-11009E83 | 27k |
| R983 | 18-83311K06 | variable; 10k |
| R993 | 6-11009E57 | 2.7k |
| R994, 997 | 6-11009E65 | 4.7k |
| R998 | 6-11009E97 | 100k |
| R1001 | 6-11009C49 | 1k |
| R1002, 1003 | 6-125D72 | 1.8 ± 10%; 1/2 W |
| R1004 | 6-11009C35 | 270 |
| R1005 | 6-11009E59 | 2.7k |
| R1006 | 6-11009E35 | 270 |
| R1007 | 6-125A20 | 62; 1/2 W |
| R1008 | 6-11009C43 | 560 |
| R1009 | 6-11009E45 | 680 |
| R1010 | 6-11009E65 | 4.7k |
| R1011 | 6-11009E81 | 22k |
| R1012 | 6-11009E35 | 270 |
| R1013 | 6-11009F14 | 470k |
| R1014 | 6-11009F06 | 220k |
| R1015 | 6-11009E35 | 270 |
| R1016 | 6-11009E59 | 2.7k |
| R1020 | 6-11009E89 | 47k |
| R1021 | 6-11009E65 | 4.7k |
| | | **integrated circuit: (see note)** |
| U401 | 51-80067C04 | quad op-amp; type M2906 |
| U501 | 51-80073C01 | quad op-amp; type M8704 |
| U502 | 51-80067C04 | quad op-amp; type M2906 |
| U901 | 51-80067C02 | dual op-amp; type M6702 |
| U1001 | 51-80067C04 | quad op-amp; type M2906 |
| | | **voltage regulator: (see note)** |
| VR1005 | 48-82256C53 | Zener type; 18 V |
| | | **hybrid, assembly:** |
| HY501 | 51-82142K12 | resistor network |
| HY502 | 51-82142K13 | resistor network |
| HY503 | 51-82142K14 | resistor network |
| HY1001 | 1-80715D03 | regulator |

**note:** For optimum performance, diodes, transistors, and integrated circuits must be ordered by Motorola part numbers.

*Common Circuits Board Schematic Diagram, Circuit Board Detail, and Parts List Motorola No. **PEPS-32280-O** (Sheet 2 of 2) 10/6/81-NPC*

MOTOROLA INC.
Communications
Group

# ROTARY-MODE-SELECT CONTROL HEAD

FAEPS–29791–O
(A535)

## 1. DESCRIPTION

1.1 The *SYNTOR X* high-band mobile radio control heads provide operational control of the radio set. All controls and switches are connected to and mounted on an internal circuit board. A power on/off slide switch, a volume control potentiometer, a squelch control potentiometer, and a rotary mode select switch provide complete operational control of the radio set. A plastic two-piece housing encloses the circuit board and controls. The knurled volume, squelch, and mode select controls project both above and below the housing to permit convenient adjustment by the operator. The power switch extends below the housing when off and above the housing when on. All control legends are illuminated and a red transmit indicator will be lighted whenever the PTT switch is pressed.

1.2 *SYNTOR X* control cable kits provide interconnection of the control head and radio set. The power cable kits provide primary power as well as transmit and receive control power to the radio set. Refer to schematic diagram at the end of this section and to the Installation Procedure for details of the radio power control cable connections.

## 2. CONTROL HEAD MAINTENANCE

### 2.1 DISASSEMBLY

Refer to Figure 1. The two captive "phillips" head screws hold the upper and lower halves of the housing together. Four optical prisms are factory aligned and mounted into the top cover of the housing. These prisms require no service and must not be tampered with for any reason.

### 2.2 BULB REPLACEMENT

Pilot bulbs can be replaced from the rear of the control head. Rotate the socket counterclockwise 45° and withdraw from the circuit board. Remove the wedge-type bulb by pulling straight out of the socket.

### 2.3 CIRCUIT BOARD & BRACKET ASSEMBLY REMOVAL

- Loosen the two captive screws and remove the upper half of the housing (refer to Figure 1).
- Remove two bracket assembly retaining screws and lift out assembly (refer to Figure 2).
- Reverse procedure to replace assembly.



technical writing services
1301 E. Algonquin Road, Schaumburg, Il. 60196
10/6/81--*NPC*
68P81048E08-O

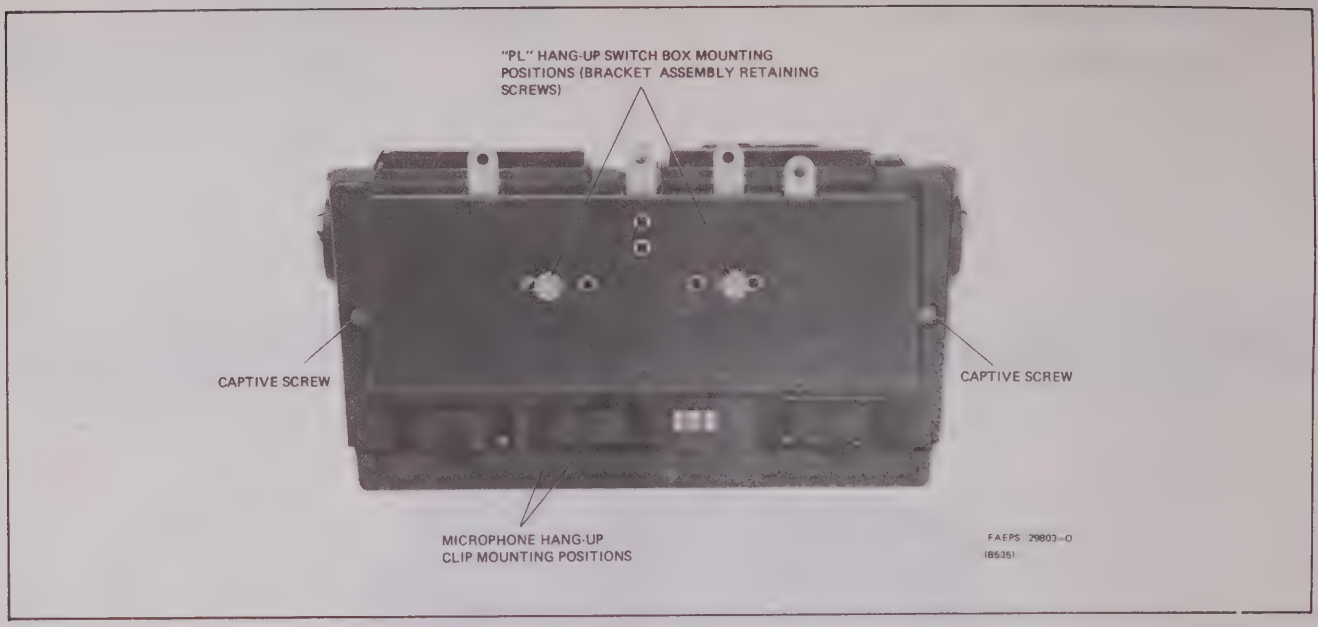

"PL" HANG-UP SWITCH BOX MOUNTING POSITIONS (BRACKET ASSEMBLY RETAINING SCREWS)
CAPTIVE SCREW
CAPTIVE SCREW
MICROPHONE HANG-UP CLIP MOUNTING POSITIONS
FAEPS 29803-O (8535)

*Figure 1. Disassembly Detail*

## 2.4 CIRCUIT BOARD REMOVAL

- Remove the circuit board and bracket assembly from the housing as described in the preceding paragraph.
- Remove the circuit board from the bracket assembly (refer to Figure 3).
- Service components mounted on the circuit board and/or bracket assembly.
- Reverse procedure to reassemble (refer to Figure 3).

## 2.5 SLIDE SWITCH AND/OR MODE SELECTOR REMOVAL

- Remove the VOLUME and SQUELCH control knobs.
- Remove the mounting nuts and lockwashers from both the VOLUME and SQUELCH controls (leave the slide switch and mode selector switch mounted to the bracket).
- Slide the circuit board and attached controls out of the bracket.
- Disconnect the leads from the slide switch and mode selector switch to the circuit board.
- Remove two "phillips" head screws holding the slide switch to the bracket and then remove the switch assembly.
- Remove the mode selector knob, indicator dial, mounting nut, and lockwasher; then remove selector switch assembly.
- Reverse procedure to reassemble.

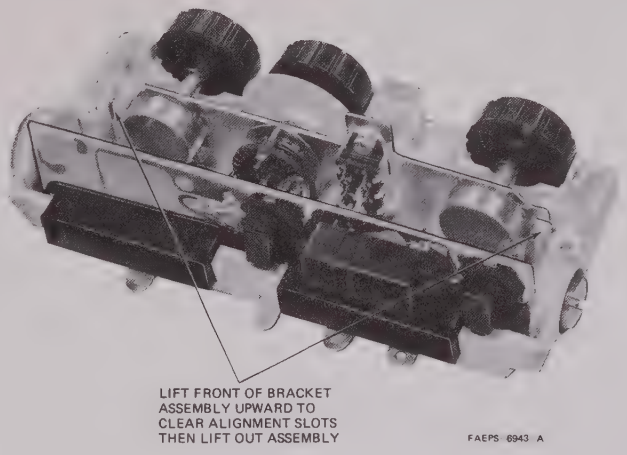



*Figure 2. Circuit Board & Bracket Assembly Removal*

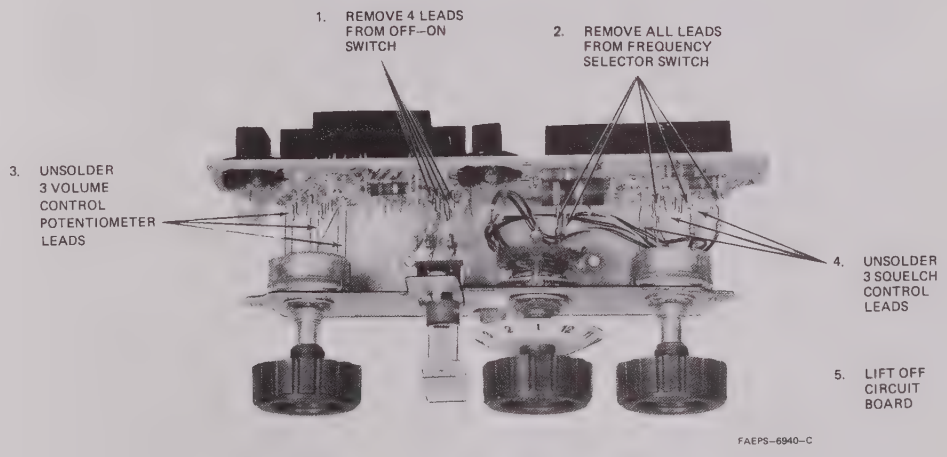
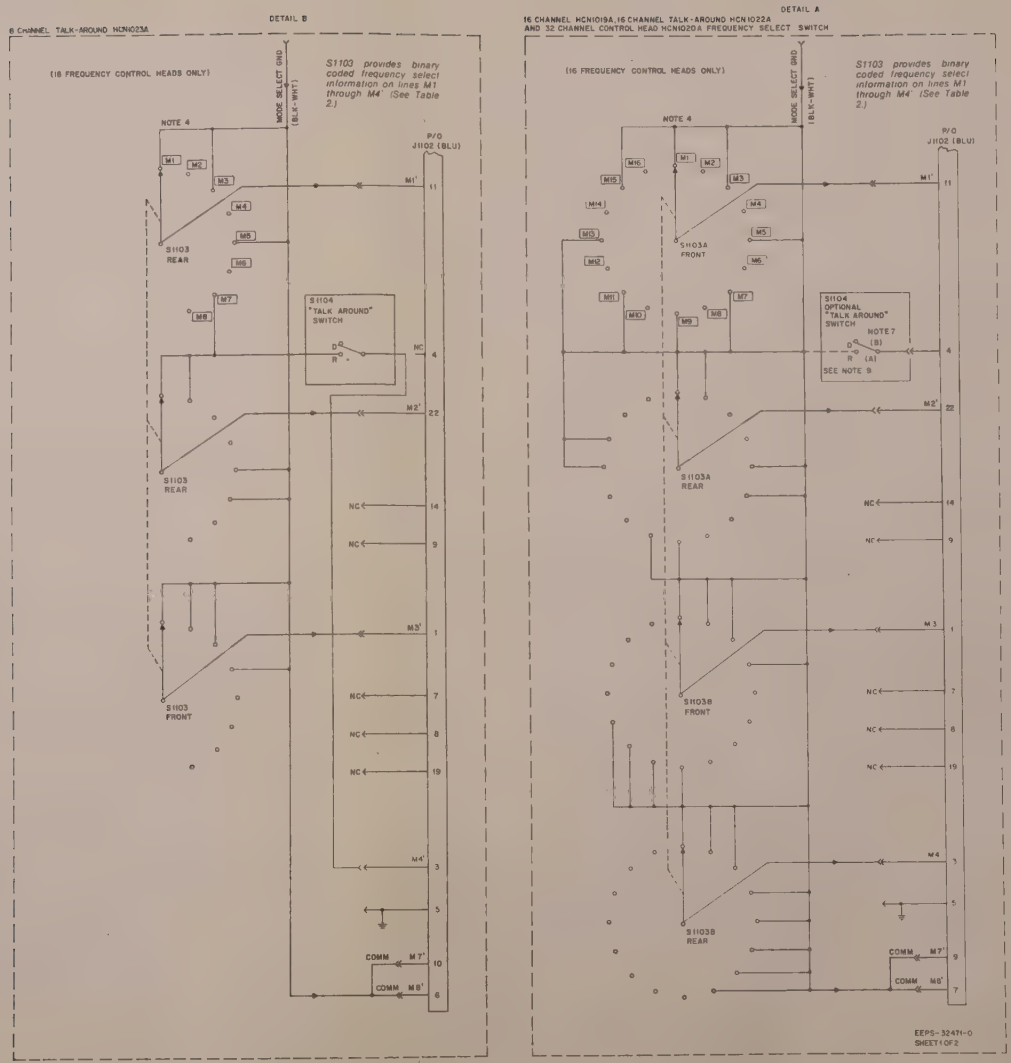
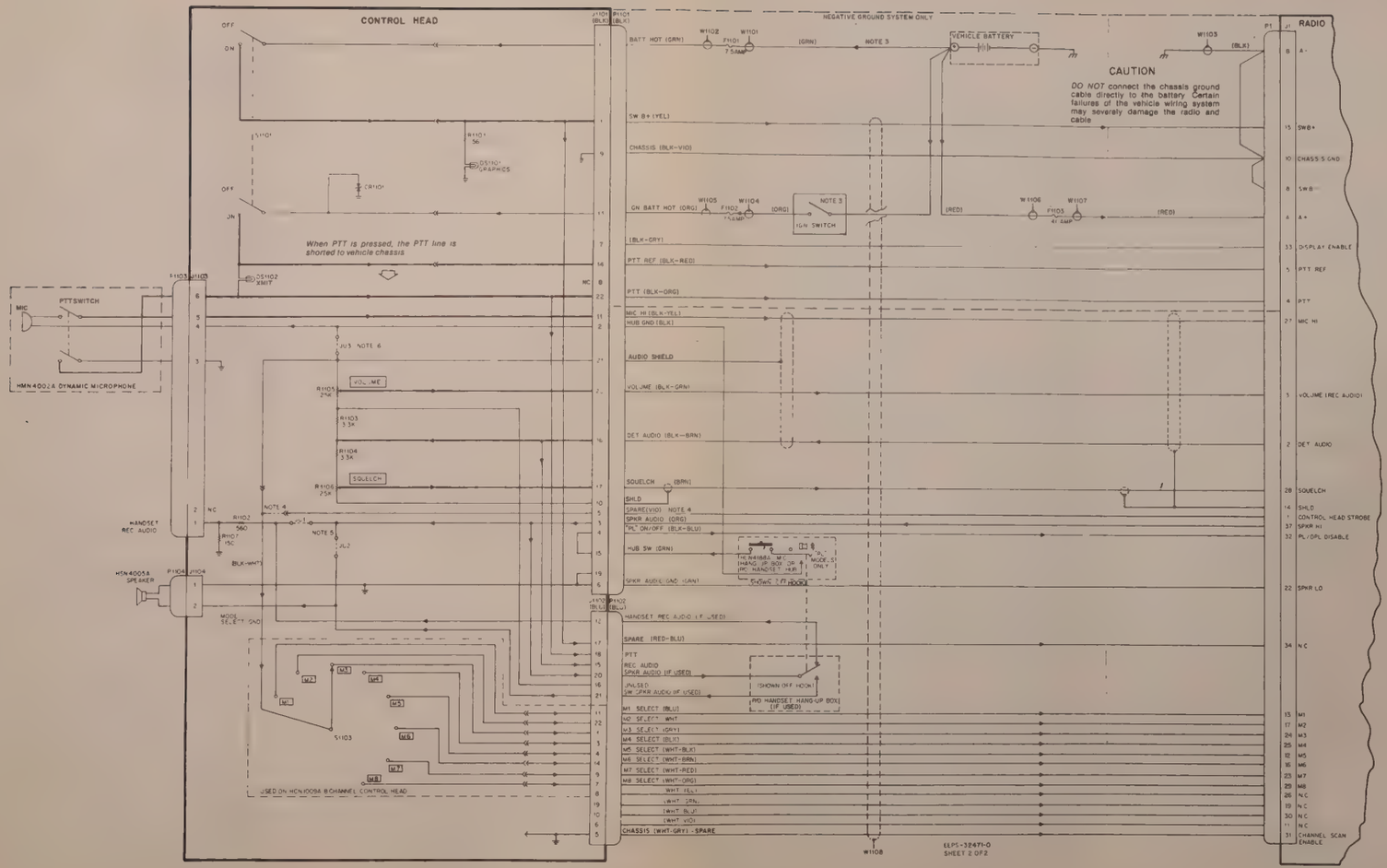
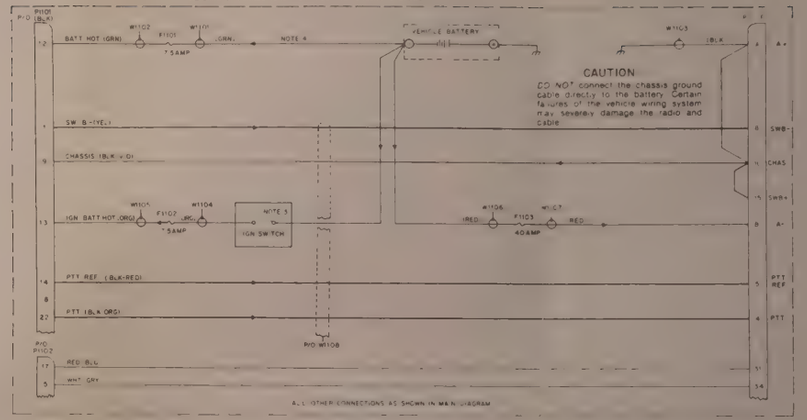

1. REMOVE 4 LEADS FROM OFF–ON SWITCH
2. REMOVE ALL LEADS FROM FREQUENCY SELECTOR SWITCH
3. UNSOLDER 3 VOLUME CONTROL POTENTIOMETER LEADS
4. UNSOLDER 3 SQUELCH CONTROL LEADS
5. LIFT OFF CIRCUIT BOARD
FAEPS–6940–C

*Figure 3. Circuit Board Removal*




*Control Head*
*Schematic Diagram, Circuit Board Detail, and Parts Lists*
*Motorola No. **PEPS-32472-O***
*(Sheet 1 of 4)*
*10/6/81-NPC*


CONTROL HEAD
NEGATIVE GROUND SYSTEM ONLY
RADIO
VEHICLE BATTERY
CAUTION
DO NOT connect the chassis ground cable directly to the battery. Certain failures of the vehicle wiring system may severely damage the radio and cable.
When PTT is pressed, the PTT line is shorted to vehicle chassis.
PTT SWITCH
MIC
HMN4002A DYNAMIC MICROPHONE
HANDSET REC AUDIO
HSN4005A SPEAKER
MODE SELECT GND
IGN SWITCH
RYO HANDSET HANG-UP BOX (IF USED)
(SHOWN OFF HOOK)
S1103
USED ON HSN1009A 8-CHANNEL CONTROL HEAD
ELPS-32471-O
SHEET 2 OF 2


DETAIL B
ALTERNATE CONNECTIONS FOR POSITIVE GROUND SYSTEMS
VEHICLE BATTERY
CAUTION
DO NOT connect the chassis ground cable directly to the battery. Certain failures of the vehicle wiring system may severely damage the radio and cable.
ALL OTHER CONNECTIONS AS SHOWN IN MAIN DIAGRAM

NOTES

1 Unless otherwise stated, all resistor values are in ohms

2 For proper operation of control heads with a voice privacy adapter (VPA) or with a handset and handset hangup box, refer to the associated instruction manual

3 The radio input power connections are shown in the recommended configuration. In this configuration the receiver portion of the radio is operable at any time the control head is switched ON but the transmitter is disabled unless the vehicle ignition switch is turned on to prevent excessive battery drain. See the installation instructions for other configurations

4 The mode select ground lead (BLK-WHT) is normally connected to SHLD GND (J1101-21) but is connected to J1101-5 in SYSTEMS 90-S channel scan and certain other special applications

5 Jumpers JU1 through JU3 modify the operation of the control head as follows:

JU1 and JU2 are normally in and may be removed when a handset and handset hangup box are used. Removal of JU1 mutes the handset speaker when the handset is on hook. Removal of JU2 mutes the external speaker when the handset is off hook.

JU3 is normally in but may be removed in special applications.

6 For proper operation of the hangup box JU3 must be present.

7 Switch S1104 is labeled A/B on 32 mode control head.

Table 1 Radio Cabling

| Model Number | Description |
|---|---|
| HKN4061A | Control Head Power Cable |
| HKN4052A | Radio Power Cable & Fuse |

Control Cable

| | Polarity | Length |
|---|---|---|
| TKN8087 | Negative Ground | 17 Feet |
| TKN8088 | Negative Ground | 22 Feet |
| TKN8084 | Negative Ground | 12 Feet |
| TKN8096 | Positive Ground | 22 Feet |

Table 2 Sixteen Frequency Channel Select Line Outputs

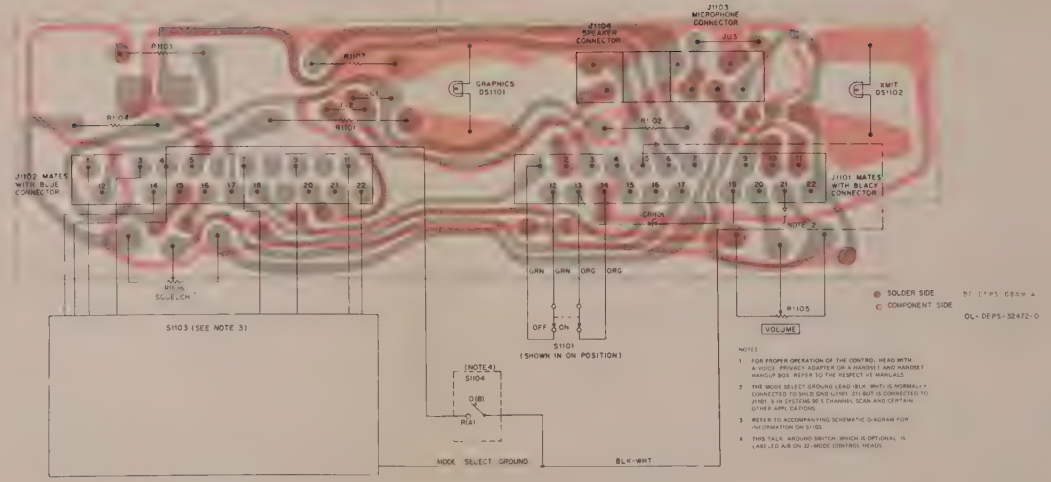
| Selected Channel | M1 | M2 | M3 | M4 |
|---|---|---|---|---|
| 1 | * | * | * | * |
| 2 | | * | * | * |
| 3 | * | | * | * |
| 4 | | | * | * |
| 5 | * | * | | * |
| 6 | | * | | * |
| 7 | * | | | * |
| 8 | | | | * |
| 9 | * | * | * | |
| 10 | | * | * | |
| 11 | * | | * | |
| 12 | | | * | |
| 13 | * | * | | |
| 14 | | * | | |
| 15 | * | | | |
| 16 | | | | |

* = Connection Made To Channel Select GND

*Control Head*
*Schematic Diagram, Circuit Board Detail, and Parts Lists*
*Motorola No. PEPS-32472-O*
*(Sheet 2 of 4)*
*10/6/81- NPC*

ROTARY-MODE-SELECT CONTROL HEAD

SHOWN FROM SOLDER SIDE


J1103 MICROPHONE CONNECTOR
J1104 SPEAKER CONNECTOR
J103
R1101
R1102
R1103
R1104
GRAPHICS DS1101
XMIT DS1102
J1102 MATES WITH BLUE CONNECTOR
J1101 MATES WITH BLACK CONNECTOR
R1106 SQUELCH
S1103 (SEE NOTE 3)
GRN GRN ORG ORG
OFF ON
S1101 (SHOWN IN ON POSITION)
(NOTE 4) S1104
D(B)
R1A1
MODE SELECT GROUND
BLK-WHT
R1105 VOLUME
NOTE 2
SOLDER SIDE
COMPONENT SIDE
BY EPS 6869 A
OL-PEPS-32472-O
NOTES
1. FOR PROPER OPERATION OF THE CONTROL HEAD WITH A VOICE PRIVACY ADAPTER OR A HANDSET AND HANDSET HANGUP BOX, REFER TO THE RESPECTIVE MANUALS.
2. THE MODE SELECT GROUND LEAD (BLK-WHT) IS NORMALLY CONNECTED TO SHLD GND (LINE 21) BUT IS CONNECTED TO J1101 9 IN SYSTEMS W/ 5 CHANNEL SCAN AND CERTAIN OTHER APPLICATIONS.
3. REFER TO ACCOMPANYING SCHEMATIC DIAGRAM FOR INFORMATION ON S1103.
4. THIS TALK AROUND SWITCH (WHICH IS OPTIONAL IS LABELED A/B ON 32-MODE CONTROL HEADS.

## parts list

HCN1009A Control Head, 8-Mode
HCN1019A Control Head, 16-Mode
HCN1020A Control Head, 32-Mode
HCN1022A Control Head, 16-Mode with Talk-Around
HCN1023A Control Head, 8-Mode with Talk-Around

PL-7485-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **diode: (see note)** |
| CR1101 | 48-83461E45 | Zener type; 25 V |
| | | **lamp, incandescent:** |
| DS1101, 1102 | 65-83554G01 | 12 V; type #161 |
| | | **connector, plug:** |
| J1101, 1102 | 29-84547B01 | (20) terminal pin; male |
| J1103 | 29-84547B01 | (5) terminal pin; male |
| J1104 | 29-84547B01 | (2) terminal, pin; male |
| | | **resistor, fixed:** |
| R1101 | 6-127C19 | 56 ± 10%; 2 W |
| R1102 | 6-125C43 | 560 ± 10%; 1/2 W |
| R1103, 1104 | 6-125C61 | 3.3k ± 10%; 1/2 W |
| R1105, 1106 | 18-84564A02 | variable; 25k |
| R1107 | 6-125C29 | 150 ± 10%; 1/2 W |
| | | **switch:** |
| S1101 | 40-84622B02 | slide, dpst |
| S1103 | 40-84149C02 | rotary; 8 position; non-shorting, includes: mounting hardware (HCN1009A) |
| | or 40-80281B01 | rotary; 16 position; includes: mounting hardware (HCN1019A, HCN1020A, HCN1022A) |
| | or 40-80285C01 | rotary; 8 position; includes: mounting hardware and (2) adjustable stop washers (HCN1023A) |
| S1104 | 40-84698K02 | toggle, spst; includes mounting, (HCN1020A, HCN1022A, HCN1023A) |
| | | **non-referenced items** |
| | 33-80035B01 | nameplate bumper |
| | 29-10134A48 | lug, connector |

**note:** For optimum performance, diodes, transistors, and integrated circuits must be ordered by Motorola part numbers.

Mechanical Parts List

PL-7486-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| 1 | 75-82619M01 | bumper, front |
| 2 | 3-124616 | screw, tapping; 6-20 x 5/16"; 2 used |
| 3 | 1-80702T37 | top cover assembly housing; includes: items 1, 2, 4, 21, 23 (used on HCN1009A, HCN1019A) |
| | or 1-80706T06 | top cover assembly housing; includes: items 1, 2, 4, 21, 23 (used on HCN1020A, HCN1022A, 1023A) |
| 4 | | prism, optical (see note) |
| 5 | TLN4369B | plate circuit board assembly; includes: J1101, 1102, 1103, 1104 and item 25 |
| 6 | 2-136272 | nut, 3/8 x 32 x 1/2"; 3 used |
| 7 | 4-2636 | washer, lock 3/8 internal; 2 used |
| 8 | 36-80024B02 | knob, control (volume & squelch); 2 used |
| 9 | 3-84548B01 | screw, cap (trunnion-mount); 2 used |
| 10 | 3-134169 | screw tapping; 4-40 x 1/4"; 2 used |
| 11 | 3-138717 | screw, tapping; 6-20 x 3/8"; 3 used |
| 12 | 36-80024B01 | knob, control; mode selector |
| 13 | 36-84006C01 | knob, disc, 8-channel switch position indicator |
| | or 36-80148B02 | knob, index 16 channel |
| 14 | 45-84004C01 | actuator, switch |
| 15 | 15-84920B02 | cover, bottom |
| 16 | 7-84005C01 | bracket, mounting |
| 17 | 1-80702T69 | switch assembly, includes: S1101 |
| 18 | 3-135084 | screw, tapping, 4-40 x 5/16"; 2 used |
| 19 | 42-84067G01 | retainer, connector |
| 20 | 9-84627B01 | socket, lamp holder |
| 21 | | prism, optical (see note) |
| 22 | 13-84000C03 | bezel (HCN1009A, HCN1019A) |
| | or 13-84000C06 | bezel (HCN1020A) |
| | or 13-84000C05 | bezel (HCN1022A, HCN1023A) |
| 23 | 33-80040B01 | nameplate |
| 24 | 38-84357C03 | plug, snap-in (single-freq. only) |
| 25 | 42-84962C01 | retainer, connector |

**note:** Items coded 4 and 2 are not individually replaceable for field-replacement, order item #3 (top cover assembly)

*Control Head*
*Schematic Diagram, Circuit Board Detail, and Parts Lists*
*Motorola No. PEPS-32472-O*
*(Sheet 3 of 4)*
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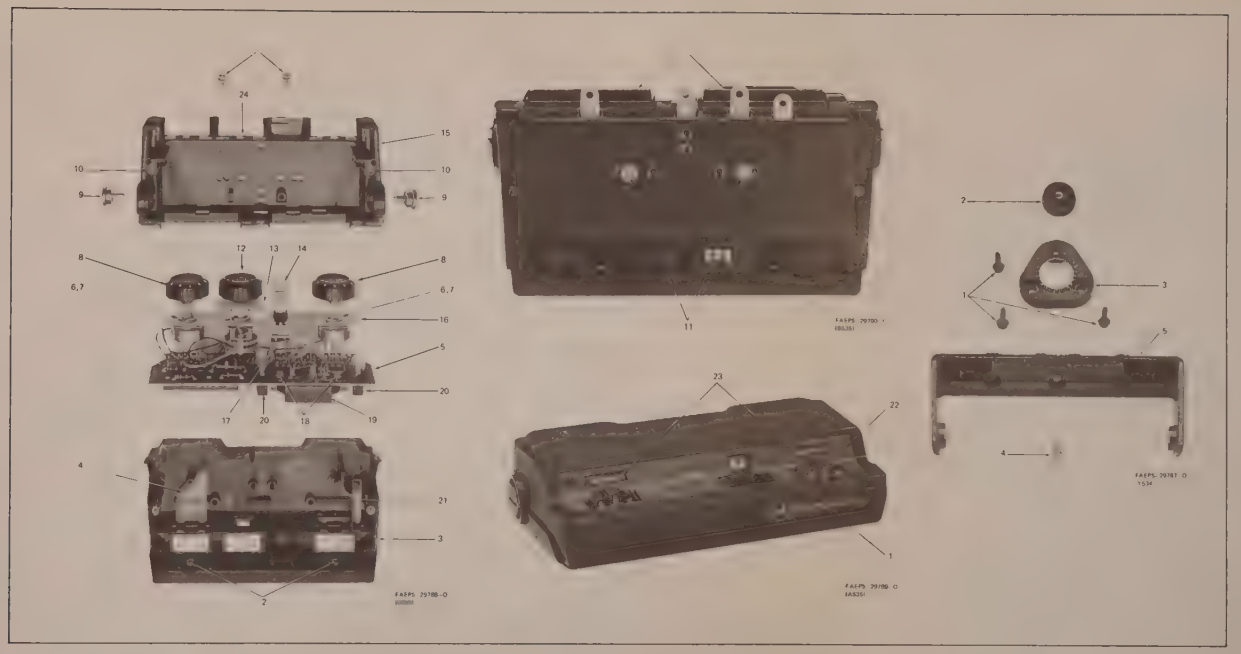


## parts list

TKN8087A Control Cable (12 Modes) Negative Ground 17"
TKN8088A Control Cable (12 Modes) Negative Ground 22'
TKN8090A Control Cable (12 Modes) Positive Ground 22'
TKN8089A Control Cable (12 Modes) Negative Ground 10' PL-7049-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **connector plug,** |
| P1 | | consists of: |
| | 15-80215B01 | housing, connector (front) |
| | 15-80216B01 | housing, connector (back) |
| | 36-80220B01 | screw, connector |
| | 42-80156B01 | ring, retainer |
| | 3-140079 | tapping screws 6-19 x 1/2 (4 used) |
| | 32-83859M01 | gasket, connector |
| | 9-80227B01 | contact, female power |
| P1101 | | consists of: |
| | 14-84556B01 | housing, connector; black, 22 position |
| | 9-84151B03 | receptacle, contact |
| P1102 | | consists of: |
| | 14-84556B02 | housing, connector; blue, 22 position |
| | 9-84151B03 | receptacle, contact |
| | | **cable assembly,** |
| W1103 | | consists of: |
| | 1-80703A58 | lead & lug assembly (BLK) includes: |
| | 29-84528B05 | lug, ring tongue |
| | 30-851875 | cable, battery; #8 ga (BLK) 66" long |
| W1107 | 30-812505 | cable; battery; #8 ga (RED) |
| | | **non-referenced items** |
| | 30-84875E01 | CABLE, 27 conductor |
| | 42-893468 | CLAMP, cable |
| | 42-893464 | HOOK, cable clip |
| | 42-10217A02 | STRAP, tie; 2 used |
| | 29-812980 | TERMINAL, closed end |
| | 29-840421 | TERMINAL, closed end |
| | 54-84032M02 | LABEL, positive ground |

TKN6456A Control Head Power Cable PL-7050-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **fuse, cartidge:** |
| F1101, F1102 | 65-86099 | 7.5 amp; 32 V |
| | | **cable assembly:** |
| W1101 | 1-80711B09 | LEAD and CLIP, assembly (GRN) includes: |
| | 30-10286C70 | WIRE, #16 ga., str. (GRN); 12" long |
| | 42-82884A01 | CLIP, fuse |
| W1102 | 1-80711B08 | LEAD and FUSE CAP (GRN); used with W1101 includes: |
| | 30-10286C70 | WIRE, #16 ga., str. (GRN); 4' long |
| | 14-82883A01 | INSULATOR, fuse holder cap |
| | 42-82884A01 | CLIP, fuse |
| | 9-84151B03 | RECEPTACLE, contact |
| W1104 | 1-80711B11 | LEAD and CLIP, assembly (ORG) includes: |
| | 30-10286G44 | WIRE, #16 ga., str. (ORG) |
| | 42-82884A01 | CLIP, fuse |
| W1105 | 1-80711B10 | LEAD and FUSE CAP (ORG); used with W1104 includes |
| | 30-10286G44 | WIRE, #16 ga., str. (ORG) |
| | 42-82884A01 | CLIP, fuse |
| | 14-82883A01 | INSULATOR, fuse holder cap |
| | 9-84151B03 | RECEPTACLE, contact |
| | | **non-referenced items** |
| | | FUSE and LEAD ASSEMBLY (GRN) includes: ref. items F1101, W1101, W1102 |
| | 14-82882A01 | INSULATOR, fuse holder body |
| | 41-82885A01 | SPRING, fuse compression |
| | | FUSE and LEAD ASSEMBLY (ORG) Includes: ref. items F1102, W1104, W1105 |
| | 14-82882A01 | INSULATOR, fuse holder body |
| | 41-82885A01 | SPRING, fuse compression |
| | 29-136968 | LUG, solder; 2 used |
| | 29-824456 | LUG, ring tongue |
| | 29-865065 | LUG, ring tongue; 2 used |

TKN6458A Power Cable and Fuse Kit PL-7051-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **fuse, cartidge:** |
| F1103 | 65-84161B01 | 40 amp; 32 V |
| | | **cable assembly:** |
| W1106 | 1-80711B12 | lead & lug assembly (RED) includes: |
| | 29-84528B05 | lug, ring tongue |
| | 30-812505 | cable, battery #8 ga. (RED) |
| | | **non-referenced items** |
| | 3-400465 | SCREW, tapping 10-12 x 3/4" |
| | 9-84277B02 | RECEPTACLE, fuse |
| | 38-84383D02 | CAP, protective |
| | 42-84275B01 | RETAINER, fuse |
| | 54-84697B01 | LABEL |

*Control Head*
*Schematic Diagram, Circuit Board Detail, and Parts Lists*
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*(Sheet 4 of 4)*
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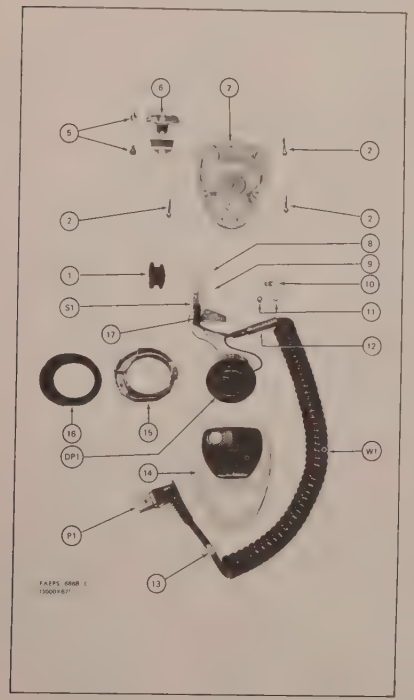
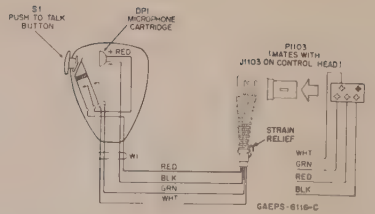
# MOBILE MICROPHONE

The mobile microphone contains the microphone element and a push-to-talk (PTT) switch. The microphone element converts speech to transmit audio signals for the radio. The PTT switch controls the radio transmitter. The microphone is supplied with a hang-up clip.






## parts list

HMN4002A Microphone — PL 6849 O

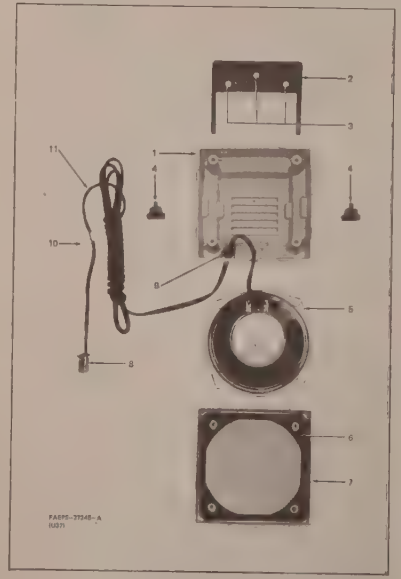
| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| DP1 | 59-83272G01 or 59-84013A01 or 59-82933C02 | **cartridge, microphone:** dynamic; includes transistor preamplifier |
| P1103 | | **connector, plug:** part of W1 |
| W1 | 1-84135C01 | **cord, microphone; coiled:** 4-conductor; includes ref. part P1, CLAMP, cable "S" hook (ref. part 13), SPRING, strain relief (ref. part 12), and non-ref. LUG (4 req'd.) 29B83277G02 |
| S1 | 40-82263G02 | **switch, push:** dpst |

HMN4002A Microphone Mechanical Parts — PL 6850 B

| CODE NUMBER | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| 1 | 38A84559B03 | PUSHBUTTON |
| 2 | 3S140000 | SCREW, tapping: #6-19 x 3/8"; 3 used |
| 5 | 3 139913 | SCREW, tapping: #6-18 x 1/2"; 2 used |
| 6 | 1V8070705 | BRACKET & SPRING ASSY (eyeletted) |
| 7 | 1-80702T35 | HOUSING, microphone, rear (PEARL) |
| 8 | 3S129498 | SCREW, lock: #6-32 x 5/16" "Phillips" round head |
| 9 | 4S7666 | LOCKWASHER: #6 external |
| 10 | 42A852710 | STRAP, strain relief |
| 11 | 3S139999 | SCREW, tapping: #6-19 x 3/4" "Phillips" round head, 2 used |
| 12 | 41A852707 | SPRING, strain relief (p/o W1) |
| 13 | 42A893647 | CLAMP, cable "S" hook (p/o W1) |
| 14 | 15-82662M23 | HOUSING, microphone, front |
| 15 | 42B82702B02 | RETAINER, cartridge |
| 16 | 32A82703B01 | GASKET, neoprene |
| 17 | 11S2506 | TUBING, #9 black; 5" length used |
| | | **non-coded items** |
| | 3-124693 | SCREW, machine: 6-32 x 1/4"; 2 used |
| | 3-132436 | SCREW, machine: 6-32 x 3/16"; 3 used |
| | 3-139999 | SCREW, tapping: 6-32 x 3/8"; 3 used |
| | 4-7669 | WASHER, lock: #6 split; 3 used |
| | 4-114201 | WASHER, flat; 3 used |
| | 13-84599B02 | EMBLEM |
| | 35-82652K01 | BAFFLE, microphone |
| | 33-82599D01 | NAMEPLATE |
| | 29-83277G02 | LUG, insulation (p/o W1); 4 used |

# SPEAKER

The mobile speaker provides the audio output from the radio. It is equipped with its own trunnion bracket and may be mounted on the firewall or dashboard near the radio. The speaker is mounted in a strong, weather-resistant housing.



## parts list

HSN4005A Mobile Speaker (8 ft. cables)
HSN4006A Mobile Speaker (25 ft. cables) — PL-6848-A

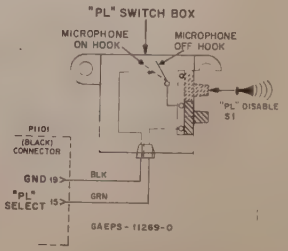
| CODE NUMBER | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| 1 | 1V80702T45 | HOUSING ASSEMBLY (rear); includes 15D84981B07 HOUSING (rear); 3-140001 SCREW, tapping, 6-19 x 7/8", "Phillips" pan head; 4 req'd. 3-132436 SCREW, machine: 6-32 x 13/16"; 4 used |
| 2 | 7C84566B02 | BRACKET, trunnion |
| 3 | 3S136756 | SCREW, tapping: #10 x 5/8" plain hex head; 3 req'd. |
| 4 | 3B84244C01 | THUMBSCREW, machine: 10-32 x 3/8"; 2 req'd |
| 5 | 50D84561B06 | LOUDSPEAKER, magnetic: 5"; "pincushion" type: 15 watt |
| 6 | 32C84564B01 | GASKET, speaker-mounting |
| 7 | 13B82671M04 | BEZEL, speaker |
| 8 | | CONNECTOR, plug; female; consists of: 14C84566B01 BODY, connector 9C84151B03 TERMINAL, contact; 2 req'd. |
| 9 | 42B82018H05 | RETAINER, cable entrance |
| 10 | 42A84061A03 | CLAMP, cable: includes "S" hook |
| 11 | 1V80703T06 | CABLE ASSEMBLY: includes 30C83155H01 CABLE, 2-conductor (8 ft.), each conductor #18 ga. stranded ("zip" cord), also includes coded items 9 and 11 (HSN4005A) |
| | or 1V80704T64 | CABLE ASSEMBLY: includes 30C83155H01 CABLE, 2-conductor (25 ft.); each conductor #18 ga. stranded ("zip" cord); also includes coded items 9 and 11 (HSN4006A) |

TRN8588A Hardware Kit — PL-6206-A

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | 7-84569B01 | BRACKET, wall mounting |
| | 7-84567B01 | BRACKET, hanger |
| | 3-121103 | SCREW, machine, 6-32 x 3/8" |
| | 3-3660 | SCREW, tapping: 6-20 x 1/2"; 2 used |

# MICROPHONE HANGUP BOX

The Model HLN4188A Microphone Hangup Box is used with "Private-Line" and "Digital Private-Line" radios to automatically place the radios in the monitor (carrier squelch) mode when the microphone is lifted off-hook. The hangup box also contains a slide switch to place the radio in the monitor mode with the microphone still on-hook.




## parts list

HLN4188A Hangup Box — PL-6847-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| S1 | 40-84622B04 | **switch:** slide, spst |
| | | **non-referenced items** |
| | 1 80704T78 | HOUSING ASSEMBLY, hangup box includes ref. item S1 |
| | 1-80704T79 | CABLE, assembly includes: |
| | 30-10136A15 | CABLE, 2-conductor, 3' used |
| | 9-84151B03 | TERMINAL, contact: female; 2 used |
| | 3-139913 | SCREW, tapping: 8-18 x 1/2"; 2 used |
| | 3-135495 | SCREW, machine: 2-56 x 3/8"; 2 used |
| | 4-8406 | WASHER, lock: #2 int., 2 used |
| | 40-84198C01 | SWITCH, stack |
| | 42-82018H07 | RETAINER, cable |

# ACCESSORIES

## HANDSET

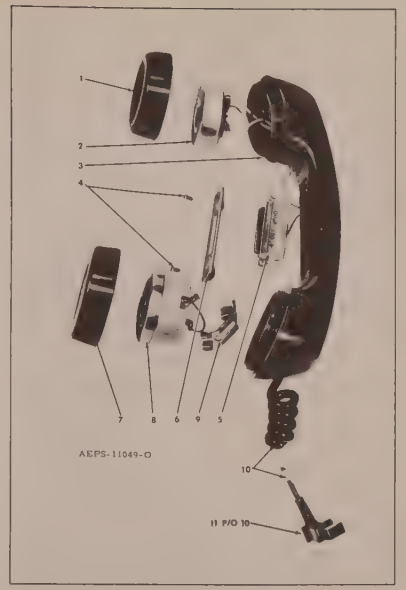
The TMN6067A Handset is used in installations where a telephone-style handset is preferred to the mobile microphone and speaker. The unit operates in the same manner as a telephone handset except that it has a PTT button which is used to key the radio.

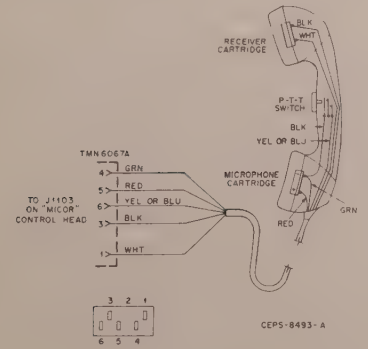
### parts list

TMN6067A Handset — PL-2241-A

| CODE NUMBER | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| 1 | 15B84054A01 | CAP, receiver (see note) |
| 2 | 59C84058A01 | CARTRIDGE, receiver |
| 3 | 15C84059A01 | HANDLE (see note) |
| 4 | 3S124432 | SCREW, machine: 4-40 x 1/4" "Phillips" flat head, 2 req'd |
| 5 | 40C84087A01 | SWITCH, push: includes pushbutton and dust cover |
| 6 | 15B84053A01 | PLATE, switch cover |
| 7 | 15B84055A01 | CAP, transmitter (see note) |
| 8 | 59B83272G01 or 59D82933C02 | MICROPHONE ELEMENT, telephone dynamic type |
| 9 | 7B83352H01 | BRACKET, cord retaining |
| 10 | 1D84519C01 | CORD ASSEMBLY: includes a "molded-on" 5-contact female connector |
| 11 | | CONNECTOR, plug, (part of Item 10) |

**note:** A replacement handle, plus transmit and receiver caps, can be obtained by ordering part no. 15C84107A01



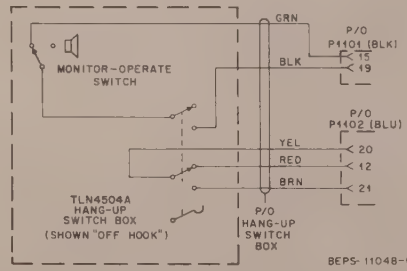

## HANDSET HANGUP BOX

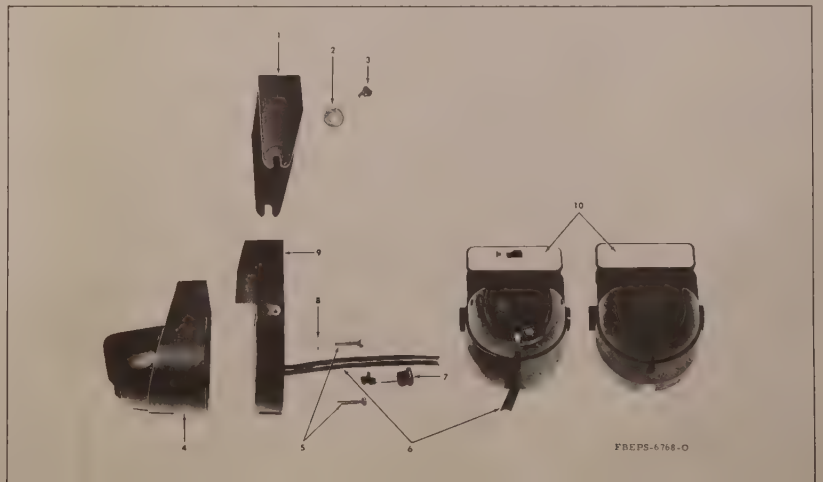
The Models TLN4504A and TLN4505A Handset Hangup Boxes are used (1) to automatically place "Private-Line" and "Digital Private-Line" radios in the monitor (carrier squelch) mode when the handset is lifted off-hook, and (2) transfer audio from the mobile speaker to the handset receiver when the handset is lifted off-hook. The Model TLN4505A Handset Hangup Box is used with carrier squelch radios and performs only the audio switching function. The Model TLN4504A Handset Hangup Box is used with "PL" or "DPL" radios and includes a monitor slide switch. When this switch is in the monitor position, "PL" squelch is disabled and the receiver operates in the carrier squelch mode.

### parts list

TLN4504A Handset Hangup Switch Box
TLN4505A Handset Hangup Cradle — PL-2240-A

| CODE NUMBER | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| 1 | 7C84566B02 | BRACKET, trunnion |
| 2 | 4S1724 | WASHER, flat: 0.234" x 0.625" x .048", 2 used |
| 3 | 3S7302 | SCREW, machine: 10-32 x 3/8" "Phillips" hex head, 2 used |
| 4 | 15C84520C01 | HANG-UP CUP & SWITCH ASSEMBLY (TLN4504A) |
| | or 15C84520C02 | HANG-UP CUP (TLN4505A) |
| 5 | 3S135507 | SCREW, machine: 6-32 x 3/4" "Phillips" hex head, 4 used |
| 6 | 1V80717B42 | CABLE ASSEMBLY: includes attached insertable connector contacts (TLN4504A) |
| 7 | 42B82018H08 | ANCHOR, cable strain relief |
| 8 | 4S1720 | WASHER, flat, 0.156" x 0.375" x .030", 2 used |
| 9 | 1V80717B40 | MOUNTING BASE & SWITCH ASSEMBLY (TLN4504A) |
| 10 | 13B84515C01 | ESCUTCHEON (TLN4504A) |
| | or 13-84515C02 | ESCUTCHEON (TLN4505A) |
| | | **non-coded items** |
| | 42B82018H08 | RETAINER, cable |
| | 3S136756 | SCREW, tapping: 10 x 5/8", 3 used |
| | 38B84383D02 | CAP, protective, 3 used |
| | 3-138392 | SCREW, tapping: 8-18 x 1-3/4"; 2 used |
| | 9-84151B03 | RECEPTACLE, contact; 3 used |
| | 14-84556B02 | HOUSING, connector: blu |



SYNTOR X™
High Band Systems Radio
150-174 MHz
75 Watts/110 Watts

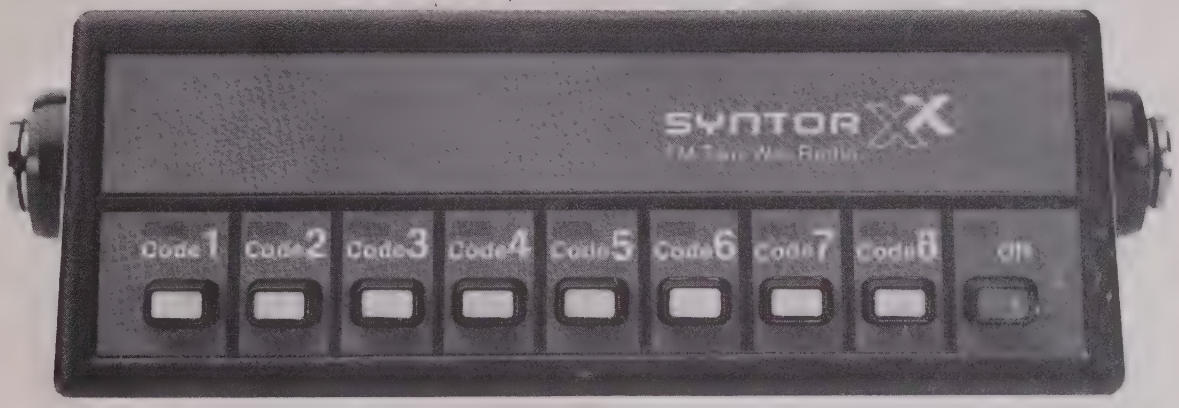
68P81060E05-O

MOTOROLA

SYNTOR X™

# SYSTEMS 90•S™

## Multiple-Coded Squelch Select Module




## Instruction Manual

68P81110E91-O

# MODEL CHART
## *SYNTOR X/SYSTEMS 90•S*
## MULTIPLE-CODED SQUELCH SELECT MODULE

● = 1 ITEM SUPPLIED

| ITEM | DESCRIPTION | TLN2254A | TLN2255A |
|---|---|---|---|
| TRN4322A | CIRCUIT BOARD, 4-CODE | ● | |
| TRN4324A | CIRCUIT BOARD, 8-CODE | | ● |
| TRN4323A | HARDWARE, 4-CODE | ● | |
| TRN4325A | HARDWARE, 8-CODE | | ● |
| TRN8097A | CABLE AND CONNECTOR | ● | ● |

EPS-31488-O

MOTOROLA INC.
Communications Group

# *SYNTOR X/SYSTEMS 90•S* MULTIPLE-CODED SQUELCH SELECT MODELS

MODELS TLN2254A & TLN2255A

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4. **TROUBLESHOOTING PROCEDURE** ..... Page 2
   TRN4322A/TRN4324A Multiple-Coded Squelch Select Board. Circuit Board Detail, Schematic Diagram, Parts List and Troubleshooting Chart (2 Sheets) ..... PEPS-31450


## 1. GENERAL

1.1 This manual provides information on Multiple-Coded Squelch Select Modules TLN2254A and TLN2255A. These modules allow the operator of a *SYNTOR X* radio to select, independently of mode, an encode/decode code pair by simply depressing a single pushbutton. The code type, be it *Private-Line* or *Digital Private Line*, or carrier squelch (CSQ), can be chosen for the decoder independently from the encoder.

1.2 The information contained in this manual covers operating instructions, functional operation, and troubleshooting procedures. The installation information is provided in Instruction Manual No. 68P81110E93, *SYNTOR X/Systems 90•S* Installation. For further information on the radio unit, refer to Instruction Manual 68P81044E40, *SYNTOR X* Two Way FM Radio (800 MHz).

1.3 The multiple-coded squelch select module can be used either with a rotary control head (refer to Manual No. 68P81044E40) or with an alternate control module, ACM (refer to Manual No. 68P81110E87).

## 2. OPERATING INSTRUCTIONS

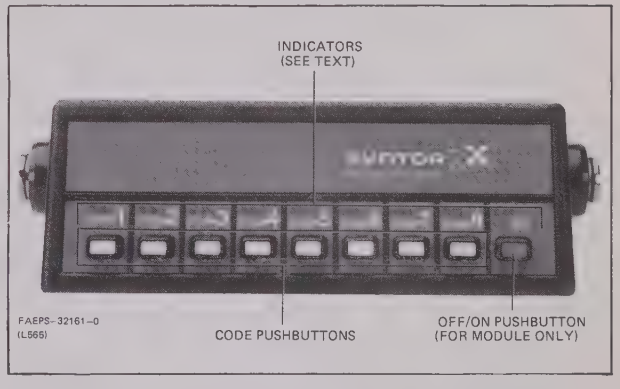


*Figure 1. Multiple-Coded Squelch Select Module Controls*

2.1 The multiple-coded squelch select module is turned on by depressing the OFF pushbutton


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4/23/81-PHI

(Figure 1) to the "in" position; this activates the radio provided that the radio is operating in a mode programmed for operator-select multipled-coded squelch.

2.2 The indicators on the module escutcheon (Figure 1) are dimly back-lit, regardless of the position of the OFF pushbutton or any CODE pushbutton on the multiple-coded squelch select module. The escutcheon light is controlled by the Off/On pushbutton on either the alternate control module (ACM) or the rotary control head.

2.3 Once the module is turned on, as described above, the required code can be selected by depressing the appropriate CODE pushbutton to the "in" position. Since the CODE pushbuttons are interlocked, only one pushbutton can be depressed at any one time. A previously-depressed CODE pushbutton will be released when depressing another CODE pushbutton to the "in" position.

2.4 The multiple-coded squelch select module is turned off by depressing the OFF pushbutton (Figure 1) and releasing it from its "out" positon; this action deactivates the module. When the module is deactivated, the radio reverts to the code operation specified in the memory module for the selected mode.

## 3. THEORY OF OPERATION

3.1 Integrated circuits U1 and U2 (refer to schematic diagram No. EEPS-31466 located at end of this manual) are used to decode the binary address assigned to the multiple-coded squelch select card. The assigned addresses are 1100 and 1110, in binary notation. The microcomputer (U8, located on the *SYNTOR X* personality board) periodically checks (at regular intervals of approximately 9 milliseconds) the switch status to determine if a change has been requested. Then it will sequentially forward the two assigned binary addresses (i.e., 1100 and 1110) on address lines M9, M10, M11, and M12 (M9 being the least significant bit, LSB).

3.2 While the address is being asserted (activated), the CONTROL HEAD STROBE signal at J2-11 (see EEPS-31446) remains low (approximately 0 V). In response to the proper address and CONTROL HEAD STROBE signals, the multiple-coded squelch select module forwards binary-coded switch information (0 to 7 in decimal notation) on data lines M1, M2, and M3 of the radio cable. The decoded address results in placing a positive enable signal at pin 5 of the priority encoder (U3-5).

3.3 The positive signal at U3-5 is used to gate the switch information present at pins 4, 3, 2, 1, 13, 12, 11, and 10 of U3 (codes 1 through 8, respectively) to output pins 6, 7, and 9 of U3. The information contained on M6 and M7 is reserved for special customer applications, whereas the information contained on M4 and M5 directs the microcomputer to the location of the coded squelch information in the memory module of the radio.

3.4 Jumpers JU8 and JU9 control the information on M4 and M5 by placing thse lines either at a high or a low level, depending on whether or not the pushbutton talk-around option exists. If this option exists, M4 goes low while M5 goes high; if this option is not used, M4 goes high while M5 goes low.

3.5 The system interprets the information at M8 as "Off/On" coded squelch. The OFF pushbutton on the multiple-coded squelch select module does not control the B+ voltage to this squelch mdoule; rather, it pulls M8 low during the presence of the proper address and low CONTROL HEAD STROBE signals, to indicate an off condition when the radio Off/On pushbutton is released (in the "out" position). When the squelch select module is turned off (by releasing the OFF pushbutton, Figure 1), the radio reverts to the code programmed for the selected mode. When the OFF pushbutton of the module (Figure 1) is pushed in, M8 floats in a high state indicating that the multiple-coded operator-select option is desired.

3.6 If a TRN4322A circuit board is used in a system, switches S1 through S4 and jumpers JU4 through JU7 are used to disable input pins 10, 11, 12 and 13 of the priority encoder (U3).

## 4. TROUBLESHOOTING PROCEDURE

4.1 Troubleshooting of the multiple-coded squelch module is facilitated by following the instructions provided in the troubleshooting flowchart (EEPS-31486) located at the end of this manual. This is a straightforward procedure which should be performed in the sequence shown. However, this chart provides two exit points to the General Troubleshooting Section in the *SYNTOR X* FM Two-Way Radio Manual (No. 68P81044E40). These exists occur at the following decision boxes:

- Is the CONTROL HEAD STROBE signal at P2-11/22 equal to 2.0 V peak-to-peak?
- Do address lines M9, M11, and M12 contain the correct information?

4.2 Reference should also be made to Tables 1 and 2 which provide useful troubleshooting information. The first table provides the data lines logic levels as function of the code, whereas the second table gives the input and output levels of the encoder (U3).

*Table 1. Data Line Logic Levels Versus the Code*

| Data Lines | Code | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| M1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| M2 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| M3 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| M4 (1) | 1/0 | 1/0 | 1/0 | 1/0 | 1/0 | 1/0 | 1/0 | 1/0 |
| M5 (1) | 0/1 | 0/1 | 0/1 | 0/1 | 0/1 | 0/1 | 0/1 | 0/1 |
| M6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M8 (2) | 1/0 | 1/0 | 1/0 | 1/0 | 1/0 | 1/0 | 1/0 | 1/0 |

**NOTES**

1. M4 and M5 are system-dependent. As illustrated above, the top half of the table shows levels for systems without pushbutton talk-around, whereas the lower half of the table shows levels for systems with pushbutton talk-around

2. The top half for mode select on, and the bottom half for mode select off.

*Table 2. Outputs of Encoder U3 Versus Its Inputs*

| | Input Pins | | | | | | | | Output Pins | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CODE | 4 | 3 | 2 | 1 | 13 | 12 | 11 | 10 | 9 | 7 | 6 |
| 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 3 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 4 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 5 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 |
| 6 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| 7 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |

## parts list

TRN4322A 4-Code Select Squelch Board
TRN4324A 8-Code Select Squelch Board — PL-7388-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **capacitor, fixed: ± 80-20%; 100 V** unless otherwise stated: |
| C1 | 21-11015A07 | .01 |
| C2 | 21-11014H35 | 33 pF ± 5% |
| C3 thru 5 | 21-11015A07 | .01 |
| C7 | 21-11015A07 | .01 |
| C8 | 25-11013E57 | 10 ± 20%; 25 V |
| C9 | 21-11015H07 | .01 |
| | | **diode (see note)** |
| CR1 | 48-83654H01 | silicon |
| | | **core:** |
| E1 thru 8 | 76-83960B01 | ferrite bead |
| | | **connector, receptacle:** consist of: |
| J1, 2 | 28-84269C01 | TERMINAL, male: low profile; 10 used |
| | 28-84269C02 | TERMINAL, male: high profile; 10 used |
| | | **coil:** |
| L1 thru 8 | 24-82723H01 | 1.2 uH |
| | | **transistor (see note)** |
| Q1, 2 | 48-869642 | NPN; type M9642 |
| | | **resistor, fixed: ± 5%; 1/4 W** unless otherwise stated |
| R1 thru 8 | 6-11009A73 | 10k |
| R9 | 6-11009E87 | 39k |
| R10 thru 18 | 6-11009E57 | 2.2k |
| R19 | 6-11009E51 | 3.3k |
| R21 | 6-11009A73 | 10k |
| R22 | 6-11009E73 | 2.2k |
| R23, 24 | 6-11009E73 | 10k |
| R25 | 6-11009E61 | 3.3k |
| R26 | 6-11009E81 | 22k |
| R27 | 6-11009H73 | 10k |
| R28 | 6-11009E61 | 3.3k |
| R43 | 6-11009A73 | 10k |
| R47 | 6-11009A73 | 10k |
| R49, 50 | 6-11009A73 | 10k |
| R56 thru 59 | 6-11009A73 | 10k |
| R60 | 6-126A36 | 270, 1 W |
| R61 | 17-82350A02 | 47 ± 10%; 1.5 W |
| | | **switch, pushbutton:** |
| S0 | 40-84324C01 | dpdt |
| S1-4 | 40-84324C09 | 4-section, 2-pole, interlocking (TRN4322A) |
| S1-8 | 40-84324C14 | 8-section, 2-pole, interlocking (TRN4324A) |
| | | **integrated circuit: (see note)** |
| U1 | 51-82884L05 | type 84L05 |
| U2 | 51-82884L04 | type 84L04 |
| U3 | 51-82884L78 | type 84L78 |
| U4, 5 | 51-84561L78 | type 81L78 |
| | | **voltage regulator: (see note)** |
| R2 | 48-82256C51 | Zener, 5.1 V |
| | mechanical parts | |
| | 39-10184A10 | CONTACT, plug: male; 8 used |
| | 29-83167C01 | TERMINAL, strain relief; 5 used |
| | 39-10184A24 | CONTACT, receptacle; 5 used |

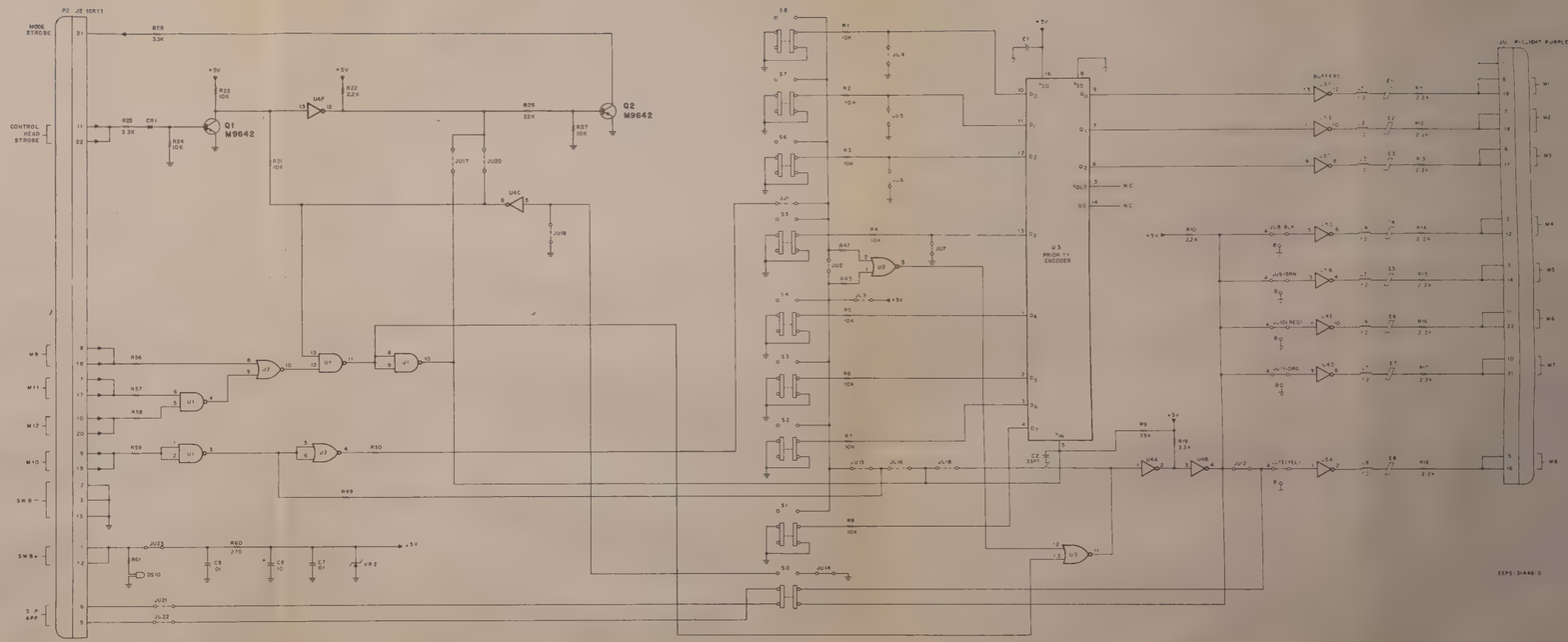
**note:** For optimum performance, diodes, transistors, and integrated circuits must be ordered by Motorola part numbers.

TKN8097A Cable and Connector — PL-7405-O

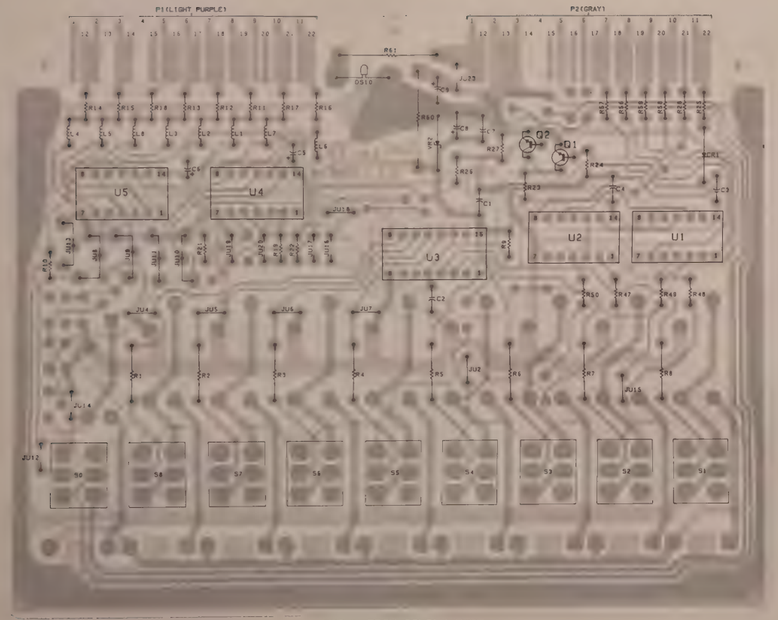
| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **connector, receptacle:** |
| J1 | 14-84556B17 | housing, light purple |
| J2 | 14-84556B11 | housing, gray |
| | | **mechanical parts** |
| | 9-84151B03 | RECEPTACLE, female; 32 used |
| | 42-10217M02 | STRAP, tie |

TRN4325A Hardware Escutcheon (8 code) — PL-7404-O

| REFERENCE SYMBOL | MOTOROLA PART NO. | DESCRIPTION |
|---|---|---|
| | | **light:** |
| DS1d | 65-83554Q01 | clear; 12 V |
| | | **mechanical parts** |
| | 13-84278M01 | ESCUTCHEON |
| | 38-80029B01 | BUTTON, push; 8 used |
| | 38-80029B02 | BUTTON, push |
| | 38-84617C01 | BUTTON, strip; 3 used |




*TRN4322A / TRN4324A Multiple-Coded Squelch Select Board*
*Circuit Board Detail, Schematic Diagram, Parts List, and Troubleshooting Chart (Sheet 1 of 2)*
*Motorola No. PEPS-31450-O*
*4/24/81-PHI*



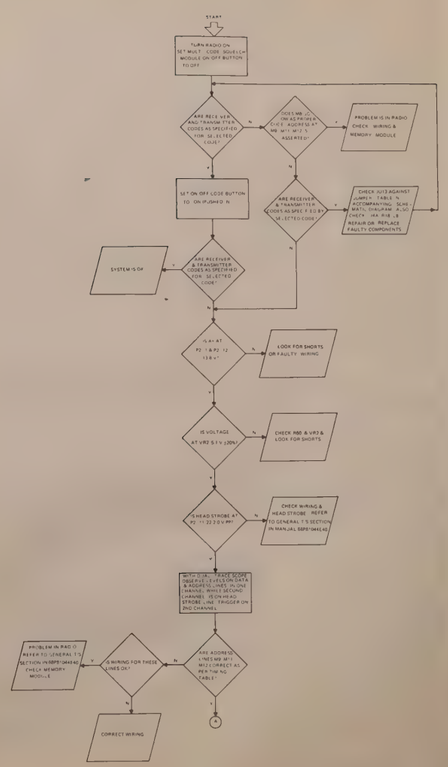

SHOWN FROM SOLDER SIDE

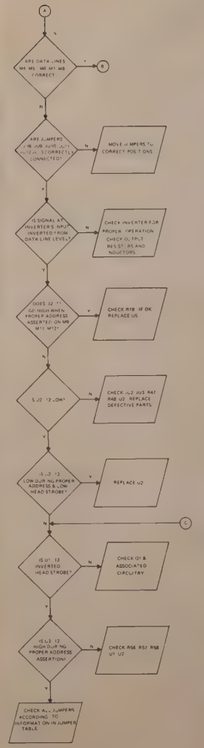
NOTE
FOR THE TRN4324A 8-CODE SQUELCH MODULE, THE FOLLOWING JUMPERS ARE REMOVED: JU4, JU5, JU6, AND JU7.

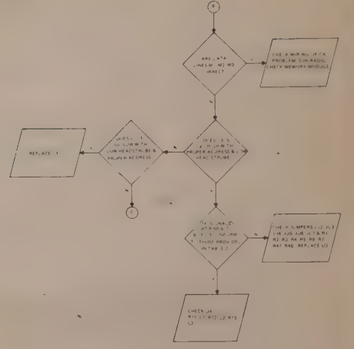
COMPONENT SIDE 80-DEPS-31447-O
SOLDER SIDE © 80-DEPS-31448-O
OL-DEPS-31448-O

*TRN4322A/TRN4324A Multiple-Coded Squelch Seleci Board Circuit Board Detail, Schematic Diagram, Parts List, and Troubleshooting Chart (Sheet 2 of 2)*
*Motorola No.* ***PEPS-31450-O***
*4/24/81-PHI*




START
TURN RADIO ON SET MULT. CODE SQUELCH MODULE ON/OFF BUTTON TO OFF
ARE RECEIVER AND TRANSMITTER CODES AS SPECIFIED FOR SELECTED CODE?
DOES MB-J2 (PIN 22) HAVE A POSITIVE VOLTAGE ASSERTED?
PROBLEM IS IN RADIO CHECK WIRING & MEMORY MODULE
ARE RECEIVER & TRANSMITTER CODES AS SPECIFIED FOR SELECTED CODE?
CHECK JU13 AGAINST JUMPER TABLE IN ACCOMPANYING SCHEMATIC DIAGRAM. ALSO CHECK J4A PINS 1-8 REPAIR OR REPLACE FAULTY COMPONENTS
SET ON/OFF CODE BUTTON TO ON (PUSHED IN)
ARE RECEIVER & TRANSMITTER CODES AS SPECIFIED FOR SELECTED CODE?
SYSTEM IS OFF
U1 PIN 12 (MB-J2 PIN 13) AT 12 VDC?
LOOK FOR SHORTS OR FAULTY WIRING
IS VOLTAGE AT VR3 5.1 V (20%)?
CHECK R80 & VR3 & LOOK FOR SHORTS
U1 PIN 8 (HEAD STROBE A*) AT 11.2-12.2 V DC?
CHECK WIRING & HEAD STROBE REFER TO GENERAL 7 SECTION IN MANUAL 68P81044E40
WITH SCOPE TRIGGERED ON DATA OUT (MB-J2 PIN 15) OBSERVE DATA (MB-J2 PIN 14) AND STROBE (MB-J2 PIN 13) WAVEFORMS. DATA ON MAIN CHANNEL, RISES SECOND CHANNEL IS ON HEAD STROBE LINE. TRIGGER ON 2ND CHANNEL
ARE ADDRESS LINES MB-M1 - M12 CORRECT AS PER THE NO TABLE?
IS WIRING FOR THESE LINES OK?
PROBLEM IN RADIO REFER TO GENERAL 7 SECTION IN MANUAL CHECK MEMORY MODULE
CORRECT WIRING


ARE DATA LINES MB-M1, MB-M2 AND MB-M3 ENABLED?
ARE JUMPERS IN AGREEMENT WITH CORRECT CONNECTS?
MOVE JUMPERS TO CORRECT POSITIONS
DO SIGNALS AT INVERTERS INPUT INVERTED FROM DATA LINE LEVELS?
CHECK INVERTER FOR PROPER OPERATION CHECK Q, TP-1 RESISTORS AND ADJUSTORS
DOES U2 (7) GO HIGH WHEN PROPER ADDRESS ASSERTED ON MB-M1 - M12?
CHECK R18 IF OK REPLACE U5
IS U2 12 VDC?
CHECK J-2 J-13 RAT R48 U2 REPLACE DEFECTIVE PARTS
IS U1 12 VDC ON OUR NO. PROPER ADDRESS & LOW HEAD STROBE?
REPLACE U2
IS U1 13 INVERTED HEAD STROBE?
CHECK Q1 & ASSOCIATED CIRCUITRY
IS U2 12 HIGH DUE TO PROPER ADDRESS ASSERTION?
CHECK R58 R57 R58 U1 U2
CHECK ALL JUMPERS ACCORDING TO INFORMAT ON IN JUMPER TABLE

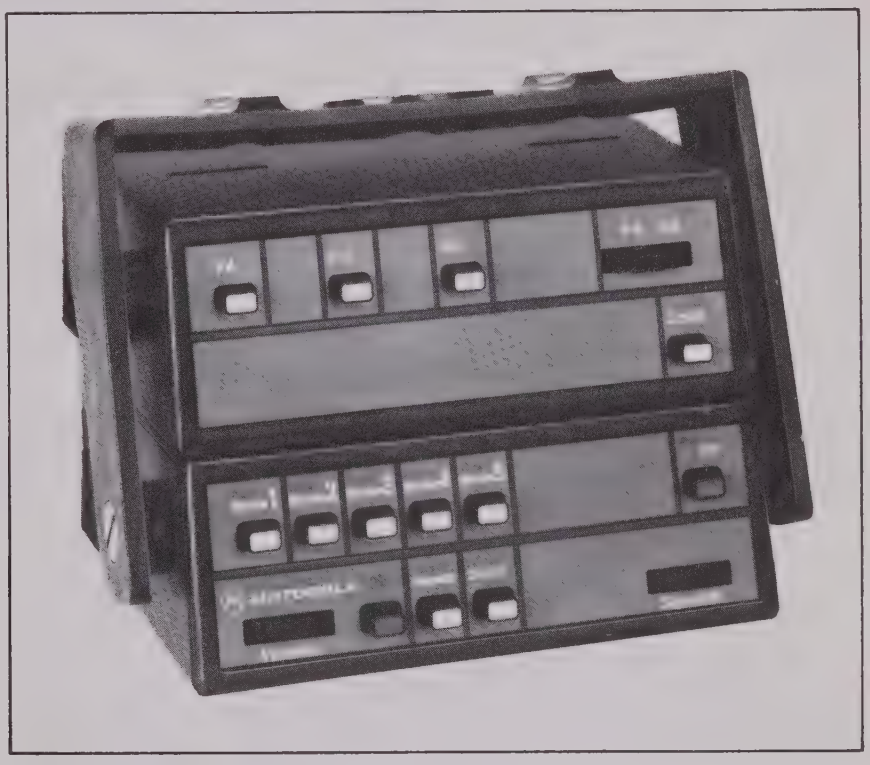

REPLACE U1
DOES U1 (7) GO HIGH WHEN PROPER ADDRESS ASSERTED?
ARE J-A WIRING, J-B FROM PROPER FOR TYPE RADIO, MEMORY MODULE
ARE J-A WIRING, J-B FROM PROPER FOR TYPE RADIO, MEMORY MODULE
DOES J-2 (PIN 13) GO HIGH WHEN PROPER ADDRESS ASSERTED ON MB-M1 - M12?
CHECK J-2 (PIN 13) FOR PROPER DC VOLTAGE (12 VDC)
CHECK U1
EEPS-31488-O

MOTOROLA

SYNTOR X™

# SYSTEMS 90•S™

## Accessory Group Installation Instructions



## Instruction Manual

68P81110E93-A

MOTOROLA INC.
Communications
Group

# *SYNTOR X SYSTEMS 90•S*

ACCESSORY GROUP
INSTALLATION INSTRUCTIONS

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### DIAGRAMS

*SYNTOR X Systems 90•S* Accessory Group Interconnection Diagram . . . . . EEPS-31908
*SYNTOR X Systems 90•S* Accessory Group Interconnection Chart . . . . . EEPS-31907
*SYNTOR X Systems 90•S* Accessory Group Interconnection Diagram Details . . . . . DEPS-31906

## 1. ACCESSORY GROUP MOUNTING INSTRUCTIONS

Step 1. Install the mounting trunnion in the vehicle, as shown in Figure 1.

Step 2. Determine the position (upper or lower) that each accessory is to occupy in each accessory housing. The alternate control module, if used, is usually placed in the lower position of the lowest accessory housing, whereas the standard control head, if used, is placed below the lowest Systems 90•S accessory housing.

Step 3. Remove the backing from the self-adhesive escutcheon for each module and carefully place the escutcheon over the appropriate front-panel position. Press each escutcheon firmly into place.

Step 4. Remove the appropriate rear-panel knock-out plates for each accessory module, as shown in Figure 2.

Step 5. Insert each accessory module circuit board into the guide rails at the predetermined location. Insert the tabs at the top of the rear cover into the slots in the top of the accessory housing. Close the rear cover and tighten the retaining screws.

Step 6. If double-unit mounting is employed, insert the clutch adapters into the trunnion extrusions of the appropriate housing — upper housing for dash mounting and lower housing for floor mounting. Assemble the accessory housings into the mounting trunnions, as shown in Figure 3. Install (but do not tighten) the mounting shoulder screws, rotate the housings to the desired position, then tighten the shoulder screws. Refer to Figure 4.

Step 7. Perform the wiring interconnections in accordance with the instructions provided in Figure 5 and Interconnection Diagram EEPS-31908. Insert the accessory module connectors into the housings, and attach the strain relief hooks to the strain relief plates, as shown in Figure 6.

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technical writing services
1301 E. Algonquin Road, Schaumburg, Il. 60196

68P81110E93-A
3-1-82 GGI

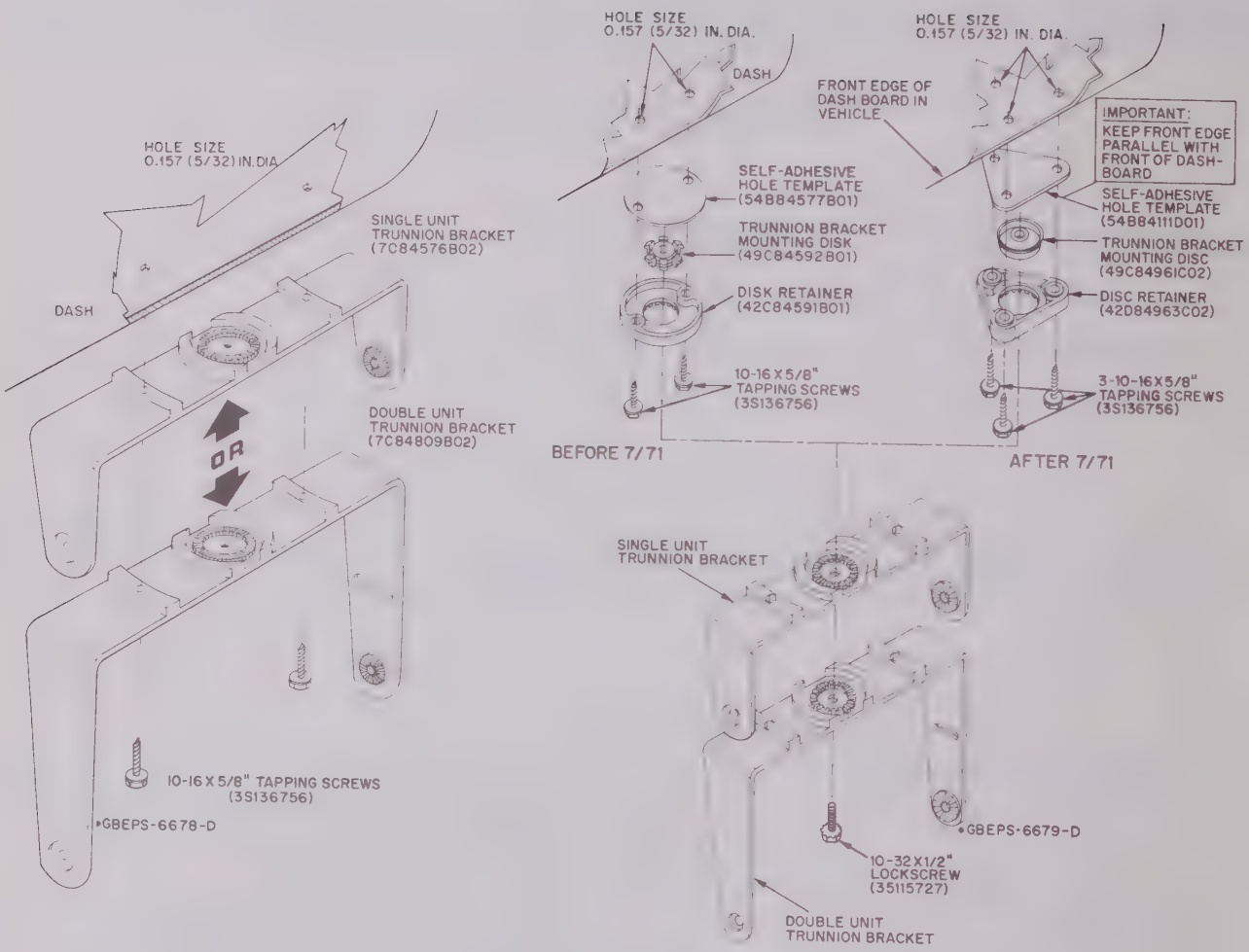
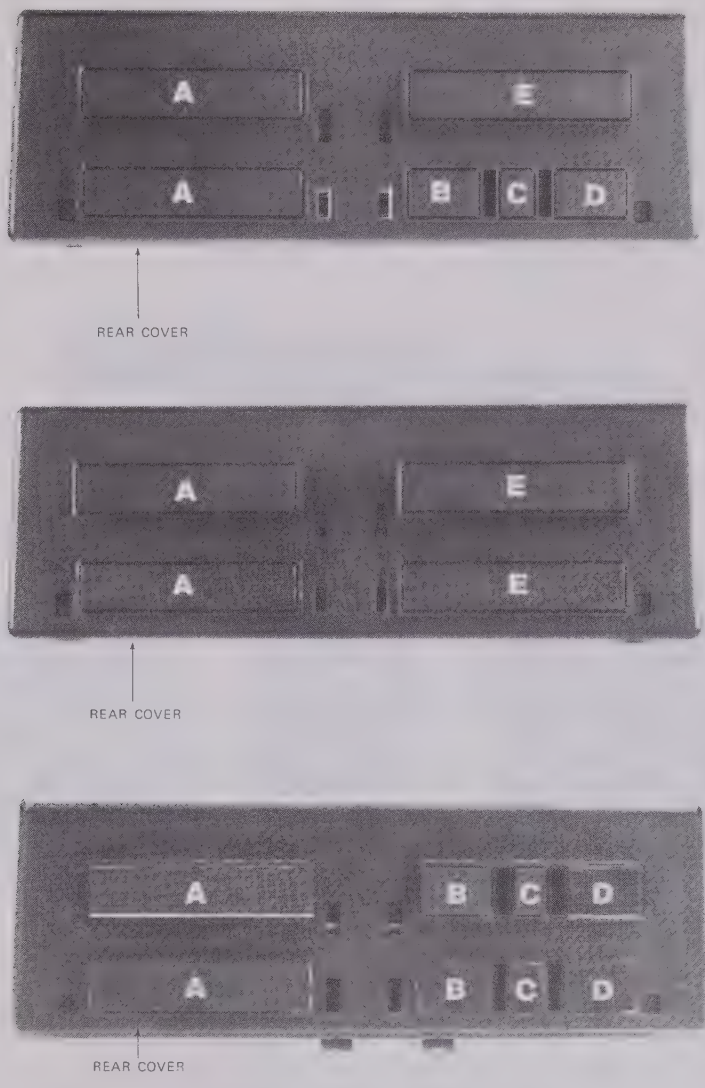



*Figure 1. Mounting Trunnion Location*




| OPTION | REMOVE AT THE APPROPRIATE (UPPER OR LOWER) LEVEL |
|---|---|
| MD, STE, MPL, OR VPA | A |
| ACM OR PAM | A, B, C, & D (DO NOT REMOVE D FOR SINGLE MODE ACM) |
| MCS, PMS, CSS, CSD, MSSD | A & E |

FBEPS-31913-O
(F540, F567, G567)

*Figure 2. Knock-Out Plate Removal*

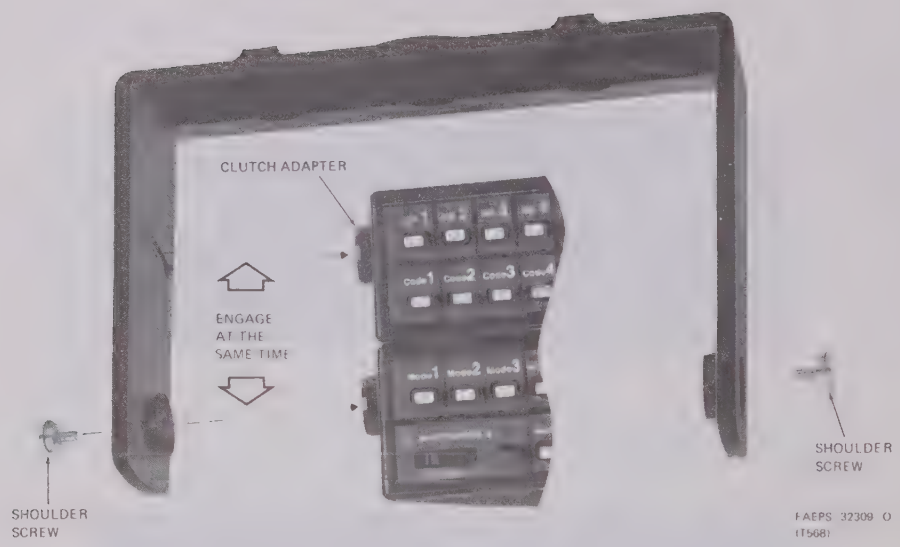


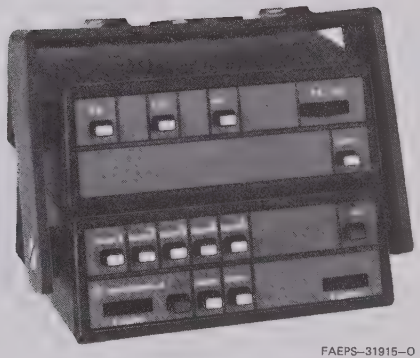

*Figure 3. Accessory Housing/Trunnion Assembly*

FAEPS–31914–O
(R568)

*Single Mount*

FAEPS–32310–O
(Q544)

*Double Mount with Standard Control Head*



FAEPS–31915–O
(R544)

*Double Mount with Alternate Control Module*

*Figure 4. Assembled Units*

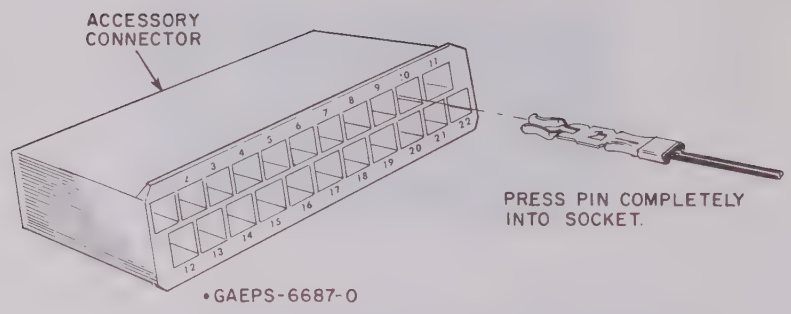



*Figure 5. Connector Pin/Housing Assembly*

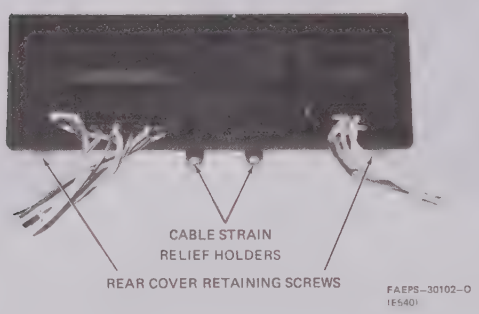



*Figure 6. Accessory Cable Installation*

**NOTE**

Information on how to use the contact removal tool (Motorola Part No. 66B84690C01) can be found in the Installation section of Instruction Manual No. 68P81044E40 (*SYNTOR X* 800 MHz FM Radio).

## 2. POSITIVE GROUND CONVERSION

The interconnection diagrams provided at the end of this manual show connections for negative-ground systems. However, the following modifications should be made to install *Systems 90•S* accessories in positive-ground systems. All other connections are common to both ground systems. Refer to paragraph 3.1 for a list of abbreviations used in this instruction section.

### 2.1 CHANNEL SCAN MONITOR (ALL *SYSTEMS 90•S* SCAN BOARDS)

- Exchange the YEL leads in P2-1/12 with the BLK/VIO leads in P2-2/13 (GRY connector on *Systems 90•S* card).
- Exchange the RED/BLU lead with the WHT/GRY leads in P1-1 (purple connector on *Systems 90•S* card).

### 2.2 PUBLIC ADDRESS MODULE (ORG CONNECTOR)

- Exchange the YEL leads from P1-1 and P1-12 with the BLK/VIO leads from P1-5 and P1-l5.
- Remove jumper JU1 from the circuit board.

### 2.3 VOICE PRIVACY ADAPTER (RED CONNECTOR)

- Exchange the YEL leads from P1-1 and P1-12 with the BLK/VIO leads from P1-14 and P1-15.
- Exchange the MIC HI lead from P1-18 with the MIC SHLD from P1-19.
- Move the VIO/BLK lead from P1-8 to P1-7.
- Remove jumper JU3 from the control head circuit board (if used) or jumper JU1101 from the alternate control module circuit board (if used).
- Move the RED/BLK lead from P1-9 of the voice privacy adapter to ACM/SCH-2 (alternate control module or standard control head). (Refer to the following paragraph which provides a list of all the abbreviations used in this manual.)
- Splice the BLK lead from the HUB (hangup box), if used, into the VIO/BLK lead in ACM/SCH-21.

### 2.4 OPERATOR SELECT CODED SQUELCH

- Exchange the YEL leads in P2-1/12 with the BLK/VIO leads in P2-2/13 (GRY connector on *Systems 90•S* card).

### 2.5 PUSHBUTTON MODE SELECT

- Exchange the YEL leads in P2-1/12 with the BLK/VIO leads in P2-2/13 (GRY connector on *Systems 90•S* card).

### 2.6 SINGLE TONE ENCODER (WHT CONNECTOR)

- Exchange the YEL leads from P1-9 and P1-19 with the BLK/VIO leads from P1-1 and P1-12.
- Exchange the ORG lead from P1-8 with the ORG lead from P1-15.
- Move the flexible jumper from position A to position B on the circuit board.
- Connect the WHT/GRY lead from the radio to P1-14 (WHT connector to STE). In applications where CSD, CSS, or MSSD is used, connect the RED/BLU lead from the radio to P1-1 (PURPLE connector to CSD, CSS, or MSSD). In applications where CSD, CSS, or MSSD are not used, connect the RED/BLU lead from the radio to SCH-17 (P1102-22, Light BLU) or tape back for ACM.

### 2.7 *TOUCH-CODE* ENCODER (DARK BLU CONNECTOR)

- Exchange the YEL lead from P1-6 with the BLK/WHT lead from P1-1.
- Exchange the YEL lead from P1-16 with the BLK/VIO lead from P1-12.

### 2.8 *QUIK-CALL II* DECODER (GRN CONNECTOR)

- In applications where the GRN lead of a hangup box is connected to P1-19 of the decoder, the BLK lead of that hangup box should be connected to ACM/SCH-19.
- In applications where the GRN lead of a hangup box is connected to P1101-15, the BLK lead of that hangup box should be connected to ACM/SCH-2 (without VPA) or spliced into the BLK/VIO lead at ACM/SCH-21 (with VPA).

### 2.9 *TOUCH-CODE* DECODER (GRN CONNECTOR)

- Exchange the YEL leads from P1-8 and P1-18 with the BLK/VIO leads from P1-2 and P1-13.

- On the decoder board, JU3 and JU6 should be out and JU4 and JU5 should be in.

- In applications where two hangup boxes are used, the two BLK leads should be spliced together and connected to ACM/SCH-2 (without VPA) or spliced into the BLK/VIO lead at ACM/SCH-21 (with VPA).

## 3. *SYNTOR X SYSTEMS 90•S* INTERCONNECTION PROCEDURE

3.1 Refer to the interconnection diagram (EEPS-31908), wiring chart (EEPS-31907), and interconnection details (DEPS-31906) provided at the end of this manual. The following abbreviations are used in this manual:

- ACM — alternate control module (P1101, unless otherwise noted)

- CSD — channel scan display

- CSS — channel scan select

- HUB — microphone or handset hangup box

- MCS — multiple code selector

- MD — mobile decoders (*Touch-Code, Quik-Call I* and *Quik-Call II* Decoders)

- MSSD — pushbutton mode select with channel scan display

- PAM — public address module (P1, unless otherwise noted)

- PMS — pushbutton mode select

- SCH — standard control head (P1101, unless otherwise noted)

- SCM — siren control module (P1, unless otherwise noted)

- STE — single tone encoder

- TCE — *Touch-Code* encoder

- VPA — voice privacy adapter

3.2 The interconnection diagram (EEPS-31908) provides the proper option order. Before connecting an option, consult the "REFER TO SECTION" column in the interconnection diagram; this column provides information on where to find any special instructions.

3.3 Special instructions, as noted on the wiring chart (EEPS-31907), are explained below.

3.3.1 Connect the BLK/GRN volume lead from the radio cable to pin 21 of the mobile decoder (MD-21) and from MD-11 to pin 19 of the public address module (PAM-19). Connect the GRN/BLK lead from PAM-8 to pin 20 of the standard control head alternate control module (SCH/ACM-20).

3.3.2 (Detected audio wiring for PAM without VPA.) Connect the BLK/BRN DETECTED AUDIO lead from the radio cable to MD-15, from MD-15 to PAM-18, and from PAM-7 to SCH/ACM-16.

- (VPA without PAM). Connect the BLK/BRN DETECTED AUDIO lead from the radio cable to MD-15, from MD-5 to VPA-3, and from VPA-2 to SCH/ACM-16 (P1101-22, BLK). Connect the BRN/BLK lead from VPA-16 to SCH-16 (P1102-22, Light BLU) or to ACM-5 (P1105-6, Light BLU).

- (VPA and PAM). Connect the BLK/BRN DETECTED AUDIO lead from the radio cable to MD-15, from MD-5 to VPA-3, and from VPA-2 to SCH/ACM-16 (P1101-22, BLK). Connect the BRN/BLK lead from VPA-16 to PAM-18 and then from PAM-7 to SCH-16 (P1102-22, Light BLU) or to ACM-5 (P1105-6, Light BLU).

**NOTE**

When a VPA is used, one of the two following resistors should be removed: R1103 from the SCH board or R1105 from the ACM circuit board. These 3.5k-ohm resistors are connected directly in series with the VOLUME control potentiometer.

3.3.3 Connect the BLK/YEL microphone output lead from the radio cable to STE-20, from STE-10 to TCE-17, and from TCE-7 to VPA-18. Connect the YEL/BLK lead from VPA-6 to ACM/SCH-11.

3.3.4 The AUDIO GROUND (shield) has no priority connections but changes to VIO/BLK when coupled from an accessory module.

3.3.5 Connect the BRN shielded squelch lead from the radio cable to PAM-13 and from PAM-2 (BLK in a RED shielded cable) to ACM/SCH-17.

3.3.6 Connect the squelch shield from the radio cable to PAM-14 and from PAM-3 to ACM/SCH-10.

3.3.7 Connect the ORG speaker audio high lead from the radio cable to PAM-20 and the ORG/BRN lead from PAM-10 to ACM/SCH-3.

3.3.8 If a mobile decoder is used, connect the BLK/BLU PL ON/OFF lead from the radio cable to MD-7; otherwise, connect this lead to ACM/SCH-4.

3.3.9 If a single tone encoder is used, connect the RED/BLU spare lead to STE-14; otherwise, connect this lead to SCH-17 (P1102-22, Light BLU), or tape back for ACM.

3.3.10 Connect the WHT/GRY SCAN ON/OFF lead from the radio cable to P1-1 (PURPLE) of any of the following modules: CSS, CSD, and MSSD. If these modules do not exist, this lead (WHT/GRY) should be connected to P1102-5 (BLU) of the SCH module or tied back (no connection) for the ACM module. If the CSS or MSSD modules are not present, verify that jumper JU1 is properly connected in the personality board of the radio. If either one of the two modules (CSS or MSSD) is present, verify that jumper JU1 is removed from the personality board of the radio.

3.3.11 The M5 (WHT/BLK) and/or M4 (BLK) leads are connected to the Repeater/Direct or 4-Group Select ACM, when a pushbutton Mode Select Module (PMS or MSSD) is present. If the M5 and/or M4 leads are connected to the ACM, the following pushbutton mode select module jumper table should be used:

*Table l.*
*Pushbutton Mode Select Module Jumper Information*

| ACM Type | Jumper Position on PMS or MSSD Module | |
|---|---|---|
| | JU7 (BLK) | JU8 (BRN) |
| RPTR/Direct | B | A |
| 4-Group Select | B | B |

**Note:** The WHT/BLK lead from ACM-3 (P1105-6, Light BLU) is required only on 32-mode (4 x 8) select installations.

3.3.12 If an STE is used, connect the ORG ignition switch lead (which is fused) to STE-15, from STE-8 to VPA-11, and from VPA-22 to ACM/SCH-13. If the STE option is not used, connect the ORG lead directly to ACM/SCH-13.

3.3.13 If a mobile decoder (MD) is used, connect the GRN HUB ground lead to MD-19; otherwise connect it to ACM/SCH-15. Moreover, if an MD is used, connect the ORG jumper from MD-22 to MD-10 for tone operation, or from MD-22 to MD-4 for tone and voice operation.

3.3.14 The microphone and speaker should be connected to the control head or to the alternate control module, except when a PAM or an SCM is used. A PAM and an SCM cannot be used in the same system.

- (If PAM is used.) Connect the radio microphone cable to the six-pin connector (outside position) on the PAM. Connect the cable supplied with the PAM between the six-pin connector (inside position) on the PAM and the six-pin microphone connector on the ACM/SCH module. Attach the external speaker to the two-pin connector on the PAM.
- (If SCM is used.) Connect the radio microphone cable to the six-pin connector (inside position) on the SCM, then connect the cable supplied with the SCM from the six-pin connector (outside position) to the six-pin microphone connector on the ACM/SCH module.

3.3.15 In a *Systems 90•S* installation using PMS, MCS, CSS, CSD, MSSD, the mode strobe must be used to control the mode lines within the ACM/SCH module. In these modules, the mode strobe is available at P2-21 (GRY connector). Connect a GRY/WHT jumper from P2-21 of any of the above-identified modules to P1101-5 (BLK) of the SCH module or P1105-4 (BLU) of the ACM. When using the SCH module with any of the following modules (MCS, CSS, CSD), disconnect the internally located mode select ground lead (BLK/WHT) from J1101-21 (SHLD GND) and connect it to J1101-5. To obtain further information, refer to the Rotary Mode Select Control Head Section in Instruction Manual No. 68P81044E40 (*SYNTOR X* FM Two-Way Radio).

3.3.16 In a system without any of the following modules (PMS, MCS, CSS, CSD, MSSD), the HEAD STROBE wire (VIO) should be connected to P1101-5 (BLK) of the ACM/SCH module.

3.3.17 When a PMS or MSSD module is used with the l-mode select ACM (TCN1352A), the M1 lead (BLU) is not connected to the ACM. If neither of these two modules (PMS or MSSD) is used, tie back the lead (no connection).

3.3.18 When the repeater/direct ACM (TCN1350A) is used with an MSSD or PMS module, the M4 line (BLK) should be connected to P1105-1 (Light BLU). When neither of these two modules (MSSD or PMS) is used, connect the M1 lead (BLU) to P1105-1 (Light BLU) and the M9 lead (WHT/YEL) to P1105-3 (Light BLU).

3.3.19 The BLK-GRY lead normally controls the display enable function and must be connected to A- for the display to be enabled. However, if a 16 (2 x 8) or 32 (4 x 8) MSSD is used, one of the following special control cables is required.

- HKN4083A 17-foot Negative Ground Cable
- HKN4084A 22-foot Negative Ground Cable
- HKN4085A 22-foot Positive Ground Cable
- HKN4086A 10-foot Positive Ground Cable

In these applications, DISPLAY ENABLE must be connected to A- via a jumper from J1-33 to J1-8 on the radio personality board. the BLK-GRY lead is then used as the SQUELCH TAIL line from J1-6 on the personality board, and is connected to P2-15 (GRY) of the MSSD.

3.3.20 The BLK-WHT lead from P2-5 (GRY) to ACM-6 (P1105-6, BLU) is for PTT indication and is used only on 16 (2 x 8) and 32 (4 x 8) MSSD.

## 4. THEORY OF OPERATION

### 4.1 INTRODUCTION

4.1.1 This manual discusses the following optional modules which are unique to the *SYNTOR X* radio:

- *Channel Scan* Display (TLN2257A, TLN2259A, TLN2261A, HLN1060A)
- Operator-Select *Channel Scan* (TLN2256A, HLN1059A)
- Operator-Select Multiple-Coded Squelch (TLN2254A, TLN2255A, HLN1057A, HLN1058A)
- *Channel Scan* Display With Mode Select (TLN2258A, TLN2260A, TLN2262A, HLN1061A, HLN1075A)
- Mode Select (TLN2267A, TLN2268A, HLN1062A)
- Control Modules (TCN1352A, TCN1351A, TCN1350A, HLN1065A, HLN1066A).

4.1.2 The *SYNTOR X* radio is compatible with a wide variety of other *Systems 90•S* options, but the options are not discussed in this manual.

4.1.3 The *SYNTOR X* radio microcomputer, which receives commands from the above-identified modules, performs the following basic functions:

- mode selection
- channel scan selection
- code selection
- mode/scan display.

4.1.4 The *SYNTOR X* radio cable kit is used to transfer data between the optional modules and the radio. Table 2 provides information on the cable kit wires, their colors and functions.

*Table 2. Syntor X Radio Cable Kit Wire Information*

| Color | J1 Cable Pin | Function |
|---|---|---|
| YEL | 15 | SW B + |
| BLK/VIO | 8 | SW B – |
| BLK/GRN | 3 | VOLUME (REC AUDIO). |
| BLK/BRN | 2 | DET AUDIO |
| BLK/YEL | 27 | MIC HI |
| SHLD | 14 | AUDIO |
| BRN | 28 | SQUELCH |
| ORG | 37 | SPKR HI |
| GRN | 22 | SPKR LO |
| BLK/BLU | 32 | PL/DPL DISABLE |
| BLK/ORG | 4 | PTT |
| ORG | | IGNITION + |
| GRN | | BATT + |
| BLK/RED | 5 | PTT REF |
| WHT/GRY | 31 | CHANNEL SCAN ENABLE |
| BLK/GRY | 33 | DISPLAY ENABLE |
| VIO | 1 | HEAD STROBE |
| BLU | 13 | MODE 1 (M1) |
| WHT | 17 | MODE 2 |
| GRY | 24 | MODE 3 |
| BLK | 25 | MODE 4 |
| WHT/BLK | 12 | MODE 5 |
| WHT/BRN | 16 | MODE 6 |
| WHT/RED | 23 | MODE 7 |
| WHT/ORG | 29 | MODE 8 |
| WHT/YEL | 26 | MODE 9 |
| WHT/GRN | 19 | MODE 10 |
| WHT/BLU | 30 | MODE 11 |
| WHT/VIO | 11 | MODE 12 |
| GRY/WHT | | MODE STROBE |
| RED/BLU | 34 | SPARE |

4.1.5 Mode lines 1 through 8 (M1-M8) are used as data lines, whereas lines M9 through M12 are used as address lines. Before the radio receives or sends information to a particular option, it forwards the binary address of the option in question on lines M9-M12 and holds the HEAD STROBE signal low. During mode selection, however, the radio holds the HEAD STROBE line high to indicate a mode selection operation, as shown in Table 3.

*Table 3. Head Strobe Levels as Function of Address Lines M9-M12*

| Binary Address on M9-M12 | Head Strobe | Function |
|---|---|---|
| 0101 | Low | Display |
| 1000 | Low | Channel Scan Modes 1-8 |
| 1001 | Low | Channel Scan Modes 9-16 |
| 1010 | Low | Channel Scan Modes 17-24 |
| 1011 | Low | Channel Scan Modes 25-32 |
| 1100 | Low | Operator-Select Coded Squelch Encode |
| 1110 | Low | Operator-Select Coded Squelch Decode |
| 1111 | High | Mode Select |

**NOTE:** M9 Represents the least significant bit (LSB) in the binary address.

### 4.2 MODE SELECTION

4.2.1 The memory module of the *SYNTOR X* radio is programmed to contain a list of the important operating characteristics of each mode. These characteristics include: receive and transmit frequencies, PL or DPL code or CSQ (carrier squelch), channel scan type, P1 (priority 1) mode, P2 mode, non-priority listing, and other types of radio information.

4.2.2 All data pertaining to a particular mode are grouped together, and all the modes are concatenated within the memory module. The mode selection process directs the microcomputer to obtain the pertinent radio operation data from a particular group (mode).

4.2.3 When mode selection information is required by the radio, it places a binary 1111 on the address lines and raises the HEAD STROBE line to approximately 2.2 volts. Consequently, all non-mode select options float (three-state) their ports on mode lines 1 through 8 (M1-M8). Now, only the mode information appears on these data lines.

4.2.4 The radio can obtain the mode selection data in two forms:

- binary, as provided by the pushbutton mode select control heads, or
- 1-of-12, as provided by the standard rotary control head.

4.2.5 In the binary system, the mode number minus one is encoded in binary form and placed on lines M1 through M6, M6 being the MSB (most significant bit), Lines M7 and M8 are held low, indicating to the radio that this information is in binary form.

4.2.6 The binary form of mode selection permits an alternate control module (ACM) to be equipped with pushbutton talk-around or group-select capability.

4.2.7 The pushbutton talk-around function controls the M4 line. When the M4 line is pulled high during talk-around, M9 through M16 can be selected by the pushbutton mode select modules (PMS or MSSD). Pulling the M4 line low, on the other hand, permits selection of modes 1 through 8. Talk-around modes 9 through 16 are identical to modes 1 through 8 in information content, with the exception of the transmit frequency. In talk-around operation, the transmit frequency is the same as the receive frequency, but in repeater type operation, the two frequencies are different from each other.

4.2.8 If the alternate control module incorporates the group-select feature, mode lines 4 and 5 are controlled by the ACM. Control of these two mode lines allows four banks of modes to be selected by means of either the PMS or MSSD module, as shown in Table 4.

*Table 4. Selection of Mode Banks*

| Group | M5 | M4 | Modes | Bank |
|---|---|---|---|---|
| A | 0 | 0 | 1-8 | 1 |
| B | 0 | 1 | 9-16 | 2 |
| C | 1 | 0 | 17-24 | 3 |
| D | 1 | 1 | 25-32 | 4 |

4.2.9 When either mode line (M5 or M4) or both mode lines (M5 and M4) are controlled by an alternate control module, the pushbutton mode select module (PMS or MSSD) must release control of the respective line(s) by floating (three-state condition) the M5 and/or M4 ports. This is done by moving the appropriate M4 and/or M5 line jumper on the code selection board from position A to position B. (See jumper table on wiring diagrams.).

4.2.10 In the 1-of-12 configuration, the mode line for the desired mode is held low. In the standard rotary control head, the selected mode line is usually held low by connecting it to ground.

4.2.11 A peculiar situation arises when other options are used in the system. Since these options use the mode lines for their information, incorrect data can be generated by holding one mode line low. This is avoided by inverting the HEAD STROBE signal on all the optional boards and forwarding it as a MODE STROBE signal. Consequently, instead of holding the desired mode line low via a ground connection, the mode strobe is used. This arrangement pulls the desired mode line low only when the HEAD STROBE line is high (mode selection); at all other times, the mode line floats high.

4.2.12 The MODE STROBE signal is provided by any optional board at P2-21 (GRY) and is forwarded to the rotary control head (SCH) via P1101-5 (BLK). The BLK/WHT wire within the rotary control head is normally connected from the wiper of the rotary switches to J1101-21 (SHLD), but when any *SYNTOR X* option is used, this wire (BLK/WHT) is connected to J1101-5 (MODE STROBE).

## 4.3 CHANNEL SCAN SELECTION

4.3.1 As stated in the previous paragraphs, the memory module includes a list of non-priority modes to be scanned. However, the memory module can be specially programmed to allow the radio to interrogate the operator-select channel scan board to determine the non-priority scan list.

4.3.2 The *SYNTOR X* radio requests the selection of a total of 32 channels configured into four banks, each with 8 channels. The channels are the receive frequencies for the modes programmed into the memory module, and are arranged in a consecutive order based on mode number rather than on frequency. The radio first forwards a binary address 1000 on address lines M9 through M12; then it looks at lines M1 through M8. If a low line is found, the mode, as defined in Table 5, is added to the scan list. Binary addresses 1001, 1010, 1011 follow, and again Table 5 defines the channel scan list for the appropriate address. Since a board can respond to one address only, four boards would be required for a 32-channel scan.

*Table 5.*
*Channel Scan List as Function of Binary Addresses.*

| | Low Line | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Address | M8 | M7 | M6 | M5 | M4 | M3 | M2 | M1 |
| 1000 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 1001 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 1010 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| 1011 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |

4.3.3 If a memory module programmed to execute a channel scan is used, the channel scan function is enabled by grounding J1-31 (WHT/GRY) of the radio. This is achieved by depressing switch S0 on the CSS or the MSSD module. If neither of these modules is used, jumper JU1 on the personality board of the radio maintains the CHANNEL SCAN ENABLE line low. JU1 must be removed when an external (to the radio) scan on/off switch is used.

## 4.4 CODE SELECTION

4.4.1 Information on the specific mode location in the memory module containing the proper code information is provided to the radio from the code selection module. This module provides a binary-encoded mode number similar to the number provided by the mode selection board discussed in the preceding paragraphs. Both boards (i.e., the code selection board and mode selection board) share many common parts. However, a major difference between both of these boards is that the code selection board responds to the binary address 1100 for the encode instruction, and to binary address 1110 for the decode information. Another difference is that, for the code selection board, lines M7 and M8 are not maintained low to indicate a binary-encoded number. The M8 line is used to indicate a request for "revert" operation. When low, this line causes the radio to revert to the code specified for the mode in which the radio is operating. When high, the M8 line causes the code selection board to select the code, as described in the previous paragraphs.

4.4.2 Although the code selection board can refer to any mode for proper code selection, special modes are usually programmed into the memory module; these special modes are accessed only by the code selection board, and are located after the normal operating modes and the pushbutton talk-around modes (if used). Since the location of these special modes may differ from one radio to another, jumpers JU8, JU9, and JU10 on the code selection board are used to control lines M4, M5, and M6 to indicate to the radio the location of the special modes. Lines M6, M5, and M4 form a binary-encoded number that indicates the proper bank of modes, as shown in Table 6, M4 being the least significant bit.

4.4.3 During normal operation, the code selection board can respond to either the encode or decode address.

## 4.5 MODE/SCAN DISPLAY

4.5.1 The binary-encoded address 0101 is employed for all display information. The transmitted information includes both channel scan activity and mode information.

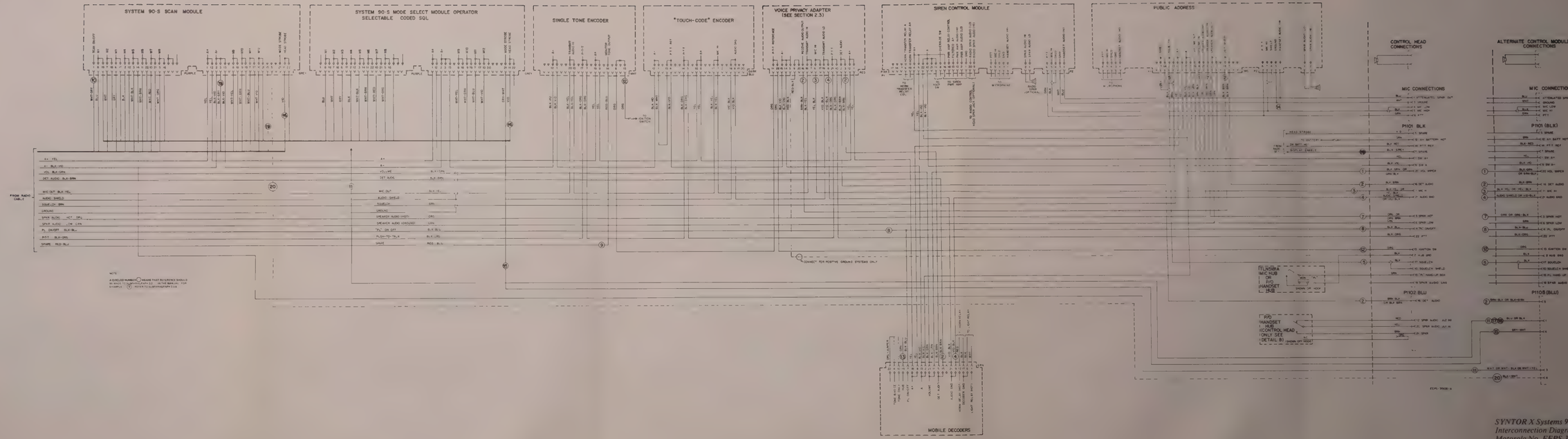
4.5.2 A binary-encoded number is placed on lines M1 through M5, M1 being the least significant digit. This facilitates the transmission of any light information indicating a mode or a channel in the range from 1 to 32 ($2^5 = 32$). Since a mode/scan display board can respond only to one bank of modes, lines M4 and M5 are decoded separately and used to enable or disable the board, depending on the way in which the board jumpers have been connected. The board jumpers can be connected so that the board responds only to a specific bank of modes.

4.5.3 In the 16 (2 x 8) and 32 (4 x 8) mode select with scan display models, the ABCD lights are slaved to their respective switches and indicate the bank of eight modes that have been selected. Consequently, the scan list for a particular mode is limited to the bank of eight modes of which the selected mode is a member.

4.5.4 The M8 line is used to drive the priority (PRI) light, whereas the M7 line is used to permit the mode information to be differentiated from the scan information. The mode information is asserted by a low on the M7 line, whereas the scan information is asserted by a high on the M7 line. Channel scan display boards employ a jumper (JU13) that disables the board when mode information is sent.

*Table 6.*
*Mode Banks as Function of Lines M6, M5, M4*

| Bank | M6 | M5 | M4 | Mode Location | JU10 | JU9 | JU8 |
|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 1-8 | A | A | A |
| 2 | 0 | 0 | 1 | 9-16 | A | A | B |
| 3 | 0 | 1 | 0 | 17-24 | A | B | A |
| 4 | 0 | 1 | 1 | 25-32 | A | B | B |
| 5 | 1 | 0 | 0 | 33-40 | B | A | A |
| 6 | 1 | 0 | 1 | 41-48 | B | A | B |
| 7 | 1 | 1 | 0 | 49-56 | B | B | A |
| 8 | 1 | 1 | 1 | 57-64 | B | B | B |




*SYNTOR X Systems 90•S Accessory Group*
*Interconnection Diagram*
*Motorola No. EEPS-31908-A*
**3-1-82 GGI**

# INTERCONNECT CHART

CONNECT WIRES FROM HERE → TO THE OPTION(S) HERE → THEN TO ONE OF THE CONTROL HEADS HERE

| CABLE FROM RADIO SET | | REFER TO NOTE | OPERATOR SELECTED SQUELCH | SINGLE-TONE ENCODER | T-C ENCODER | VOICE PRIVACY ADAPTER | MOBILE DECODERS | CHANNEL SCAN MONITORS (INCLUDING MSSD) | PUBLIC ADDRESS | SIREN | MODE SELECT MODULE (PMS) | | STANDARD CONTROL HEAD | | ACM, 1 MODE SELECT | | ACM, 2 MODE SELECT | | ACM, RPTR/DIRECT | | ACM, 4 GROUP SELECT | | CABLE FROM RADIO SET | | ACM, 16/32 MODE SELECT | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WIRE COLOR | FUNCTION | SECTION | PURPLE | WHT CONNECTOR | DARK BLU CONNECTOR | RED CONNECTOR | GRN CONNECTOR | PURPLE | GREY | ORG CONNECTOR | PINK CONNECTOR | PURPLE | GREY | P1101(BLK) | P1102(BLU) | P1101(BLK) | P1105(BLU) | P1101(BLK) | P1105(BLU) | P1101(BLK) | P1105(BLU) | P1101(BLK) | P1105(BLU) | WIRE COLOR | FUNCTION | P1101(BLK) | P1105(BLU) |
| YEL | A+ | | | 19*9 | 16*6 | 12*1 | 18*8 | | 1*12 | 12*1 | 4*5 | | 1*12 | 1 | | 1 | | 1 | | 1 | | 1 | | YEL | A+ | 1 | |
| BLK-YEL | A- | | | 12*1 | 12*4 | 15*14 | 13*2 | | 2*13 | 15*5 | 22*10 | | 2*13 | 9 | | 9 | | 9 | | 9 | | 9 | | BLK-YEL | A- | 9 | |
| BLK-GRN | VOLUME | 3*3*1 | | | | | *21*11 | | | ** ▶19*8▶GRN-BLK | | | | 20 | | 20 | | 20 | | 20 | | 20 | | BLK-GRN | VOLUME | 20 | |
| BLK-BRN | DISCRIMINATOR | 3*3*2 | | | | **3*2 | *15*5 | | | *** 18*7(WITHOUT VPA) | | | | 16 | | 16 | | 16 | | 16 | | 16 | | BLK-BRN | DISCRIMINATOR | 16 | |
| BLK-YEL | MIC HI | 3*3*3 | | 20*10 | 17*7 | ** ▶18 OR 7 17OR 6 ▶YEL-BLK | | | | | | | | 11 | | 11 | | 11 | | 11 | | 11 | | BLK-YEL | MIC HI | 11 | |
| SHIELD | AUDIO GND | 3*3*4 | | | ▶18*8▶VIO BLK | ▶19*8▶VIO-BLK | ▶20*9▶VIO-BLK | | | | | | | 21 | | 21 | | 21 | | 21 | | 21 | | SHIELD | AUDIO GND | 21 | |
| BRN | SQ.ELCH | 3*3*5 | | | | | | | | *13*2 | | | | 17 | | 17 | | 17 | | 17 | | 17 | | BRN | SQ.ELCH | 17 | |
| SHIELD | SQ.ELCH GND | 3*3*6 | | | | | | | | *14*3 | | | | 10 | | 10 | | 10 | | 10 | | 10 | | SHIELD | SQ.ELCH GND | 10 | |
| ORG | SPKR AUDIO HI | 3*3*7 | | | | | | | | ▶20*10▶ORG-BRN | | | | 3 | | 3 | | 3 | | 3 | | 3 | | ORG | SPKR AUDIO HI | 3 | |
| GRN | SPKR AUDIO LO | | | | | | | | | 22*11 | | | | 6 | | 6 | | 6 | | 6 | | 6 | | GRN | SPKR AUDIO LO | 6 | |
| BLK-BLU | PL ON/OFF | | | | | | 7(PL ONLY) | | | | | | | 4 | | 4 | | 4 | | 4 | | 4 | | BLK-BLU | PL ON/OFF | 4 | |
| BLK-ORG | PTT | 3*3*8 | | | | | | | | | | | | 22 | | 22 | | 22 | | 22 | | 22 | | BLK-ORG | PTT | 22 | |
| BLK-RED | | | | 17*7 | 14*3 | 21*10 | | | | | | | 11*22 | 5 | | 5 | | 5 | | 5 | | 5 | | LBO | HEAD STROBE | | |
| BLK-WHT | HEAD STROBE | 3*3*15 | | | | | | | 11*22 | | | | 21 | 5 | | | 4 | | 4 | | 4 | | 4 | GRY-WHT | MODE STROBE | | 4 |
| GRY-WHT | MODE STROBE | 3*3*15 | | 11*22 | | | | | 21 | | | 1 | | | 5 | | | | | | | | | WHT-GRY | SCAN ON/OFF | | |
| WHT-GRY | SCAN ON/OFF | 3*3*10 | | 21 | | | | *1 | | | | | | | 17 | | | | | | | | | RED-BLU | SPARE | | |
| RED-BLU | SPARE | 3*3*9 | | 14 | | | | | | | | | | | | | | | | | | | | | | | |
| BLK-RED | PTT REF | | | | | | | | | | | | | 14 | | 14 | | 14 | | 14 | | 14 | | BLK-RED | PTT REF | 14 | |
| BLK-GRY | DISPLAY ENABLE | 3*3*19 | | | | | | | *3 | | | | | 7 | | 7 | | 7 | | 7 | | 7 | | BLK-GRY | DISPLAY ENABLE | @ 3*3*19 | |

ADDITIONAL CONNECTION

| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RED | IGNITION (FUSED) | 3*3*12 | | ▶15*8▶ | | **22*11 | | | | | | | | 13 | | 13 | | 13 | | 13 | | 13 | | ORG | IGNITION (FUSED) | 13 | |
| GRN | BATTERY (FUSED) | | | | | | | | | | | | | 12 | | 12 | | 12 | | 12 | | 12 | | GRN | BATTERY (FUSED) | 12 | |
| BLK | MIC HANG UP BOX | | | | | | 19 | | | | | | | 2 | | 2 | | 2 | | 2 | | 2 | | BLK | MIC HANG UP BOX | 2 | |
| GRN | MIC HANG UP BOX | 3*3*13 | | | | | 12 | | | | | | | 15 | | 15 | | 15 | | 15 | | 15 | | GRN | MIC HANG UP BOX | 15 | |
| WHT | LIGHT RELAY | | | | | | 17*6 | | | | | | | | | | | | | | | | | WHT | LIGHT RELAY | | |
| RED | HORN RELAY | | | | | | | | | | | | | | | | | | | | | | | RED | HORN RELAY | | |
| BLK | RELAY GND | | | | | | | | | | | | | | | | | | | | | | | BLK | RELAY GND | | |
| | SPEAKER | 3*3*14 | | | | | | | | | | | | SPEAKER CONNECTOR | | SPEAKER CONNECTOR | | SPEAKER CONNECTOR | | SPEAKER CONNECTOR | | SPEAKER CONNECTOR | | SPEAKER | | | |
| | SPEAKER | 3*3*14 | | | | | | | | | | | | SPEAKER CONNECTOR | | SPEAKER CONNECTOR | | SPEAKER CONNECTOR | | SPEAKER CONNECTOR | | SPEAKER CONNECTOR | | SPEAKER | | | |
| RED-BLK | POS. GND JUMPER | | | | | 5 ▶ 8 | | | | | | | | | | | | | | | | | | RED-BLK | POS. GND JUMPER | | |
| ORG | EXT. JUMPER | | | | | | 22 ▶ 4 OR 10 | | | | | | | | 16 | | 5 | | 5 | | 5 | | 5 | ORG | EXT. JUMPER | | |
| BRN-BLK | V.P.A. OUT | | | | 15*1 | 16▶ | | | 5@3*3*20 | 18*7(WITH VPA) | | | | | | | | | | | | | | BRN-BLK | V.P.A. OUT | | 5 |
| BLK-WHT | PTT REF./INDICAT. | | | | | | | 8*19 | | | | 8*19 | | | 11 | | 1@3*3*18 | | 1 | | 1@3*3*18 | | | BLK-WHT | PTT REF./INDICAT. | | 6@3*3*20 |
| BLU | M1 | 3*3*17 | 8*19 | | | | | 7*18 | | | | 7*18 | | | 22 | | | | 3 | | | | | BLU | M1 | | |
| WHT | M2 | | 7*18 | | | | | 6*17 | | | | 6*17 | | | 1 | | | | | | | | | WHT | M2 | | |
| GRY | M3 | | 6*17 | | | | | 2*12 | | | | 2*12 | | | 3 | | | | | | 1@3*3*18 | | 1 | GRY | M3 | | |
| BLK | M4 | 3*3*11 | 2*12 | | | | | 3*14 | | | | 3*14 | | | 4 | | | | | | | | 3 | BLK | M4 | | 1 |
| WHT-BLK | M5 | 3*3*11 | 3*14 | | | | | 11*22 | | | | 11*22 | | | 14 | | | | | | | | | WHT-BLK | M5 | | 3 |
| WHT-BRN | M6 | | 11*22 | | | | | 10*21 | | | | 10*21 | | | 9 | | | | | | | | | WHT-BRN | M6 | | |
| WHT-RED | M7 | | 10*21 | | | | | 5*16 | | | | 5*16 | | | 7 | | | | | | | | | WHT-RED | M7 | | |
| WHT-ORG | M8 | | 5*16 | | | | | | 8*18 | | 8*18 | | | | 8 | | 1@3*3*18 | | | | | | | WHT-ORG | M8 | | |
| WHT-GRN | M9 | | | 8*18 | | | | | 9*19 | | 9*19 | | | | 19 | | | | | | | | | WHT-GRN | M9 | | |
| WHT-BLU | M10 | | | 9*19 | | | | | 7*17 | | 7*17 | | | | 10 | | | | | | | | | WHT-BLU | M10 | | |
| WHT-VIO | M11 | | | 7*17 | | | | | 10*20 | | 10*20 | | | | 6 | | | | | | | | | WHT-VIO | M11 | | |
| WHT-VIO | M12 | | | 10*20 | | | | | | | | | | | | | | | | | | | | | | | |

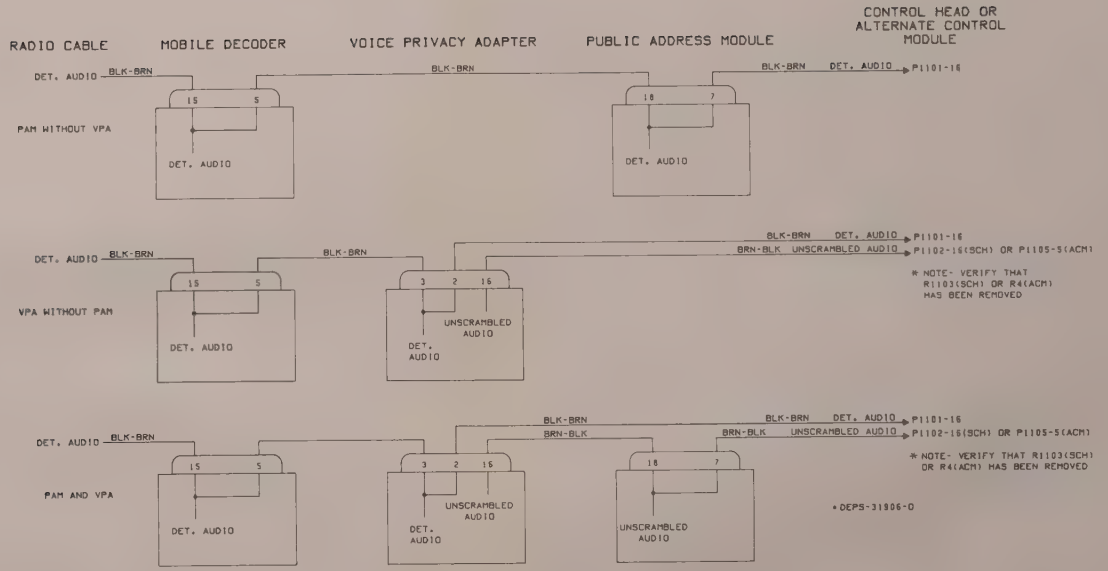
PP/EPS-31907
(SHEET 1)

LEGEND-

- ⊛ REFERS TO NOTE NUMBER.
- →▪ REFERS TO LEAD GOING TO A PIN.
- ▪→ REFERS TO LEAD COMING FROM A PIN.
- * INDICATES FIRST PRIORITY ACCESSORY. LEADS MUST GO TO THIS MODULE FIRST IF MULTIPLE MODULES ARE CONNECTED.
- ** INDICATES SECOND PRIORITY ACCESSORY.
- *** INDICATES THIRD PRIORITY ACCESSORY.

PP/EPS-31907-A
(SHEET 2)

*SYNTOR X Systems 90•S Accessory Group*
*Interconnection Chart*
*Motorola No. EEPS-31907-A*
3-1-82 GGI




*SYNTOR X Systems 90•S Accessory Group*
*Interconnection Diagram Details*
*Motorola No. DEPS-31906-O*
**3-1-82 GGI**

MP MASTER
MA36322